INTER AVIA

Review of World Aviation

In this Issue:

Tired Lion?

IATA Achievements and Aims — Space Flight?

S. Bangs : Inherent Stability — E. Saenger : Jet Reaction Flight

Twin-Engined Civil Transports — Airliner Cockpit Planning

Air-Sea Rescue — Month in Review

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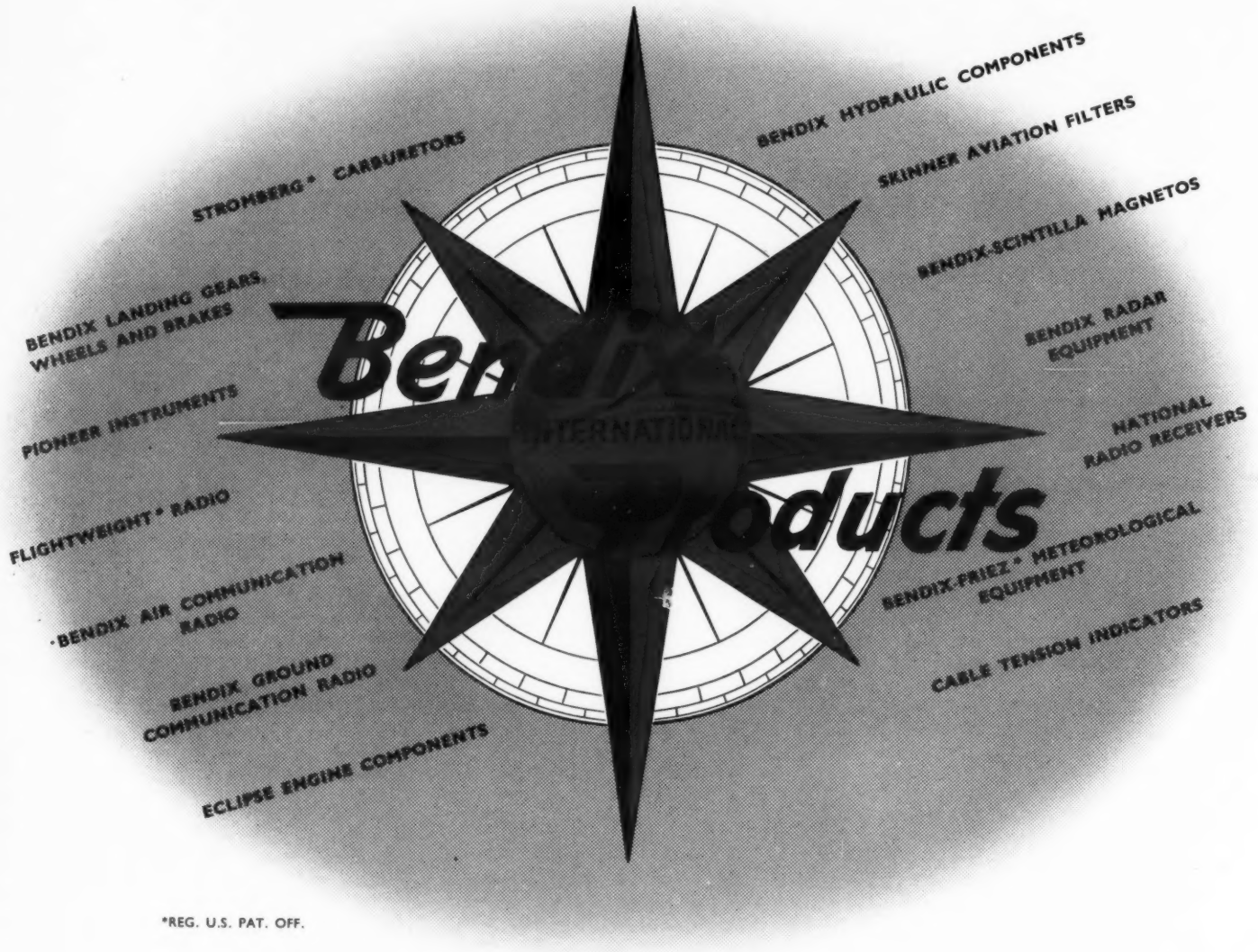

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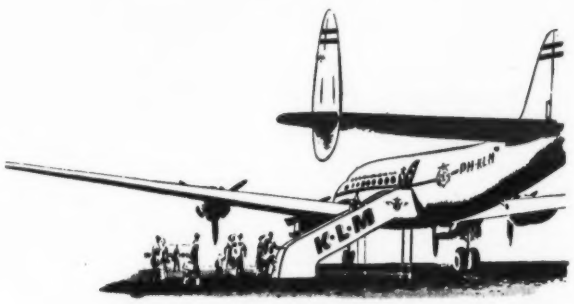

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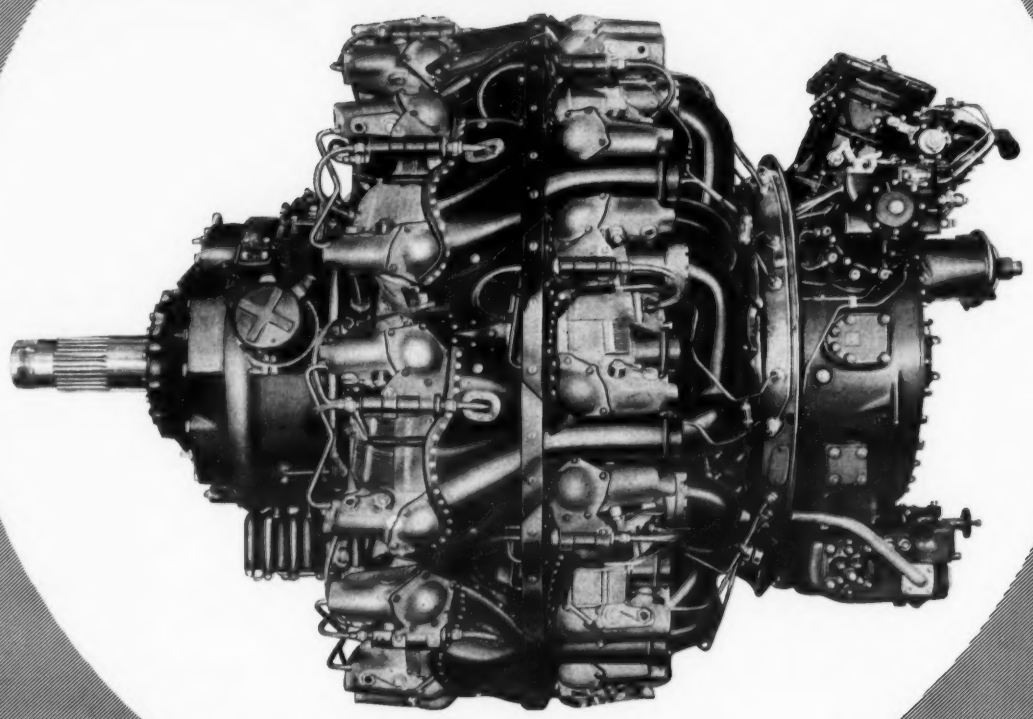

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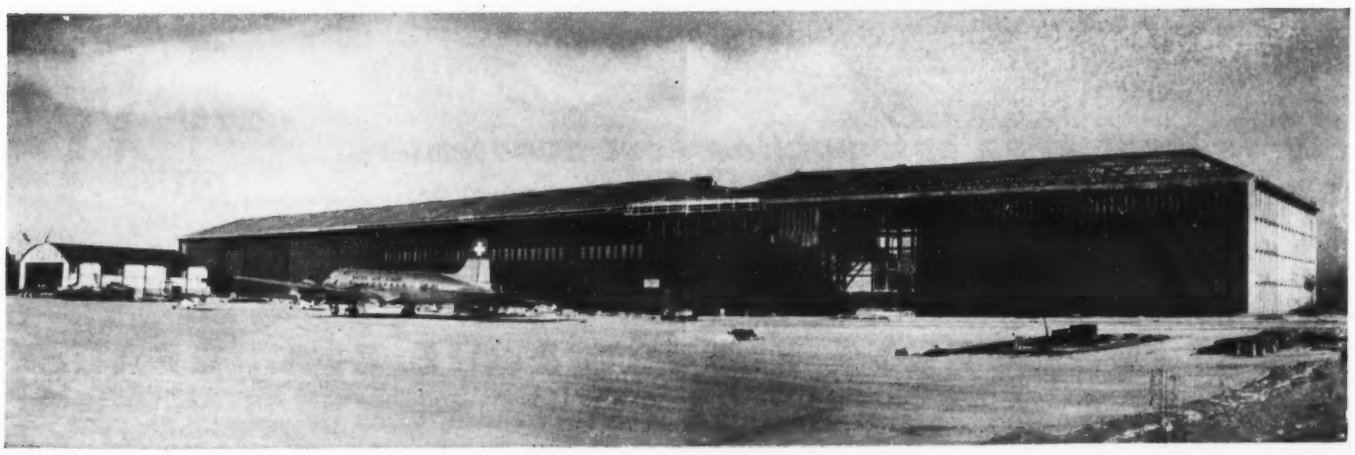

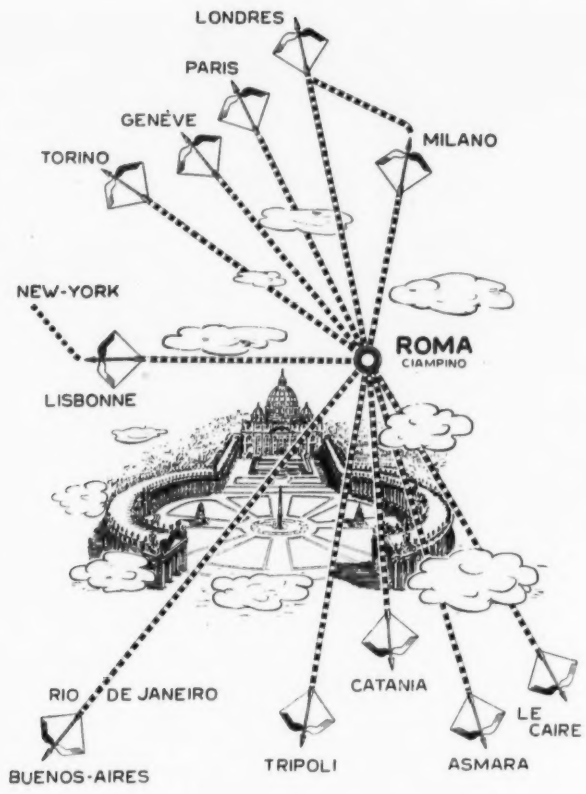

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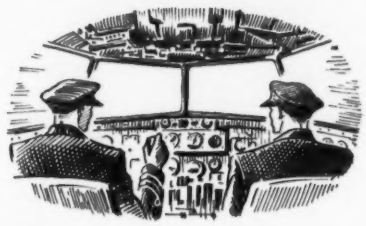

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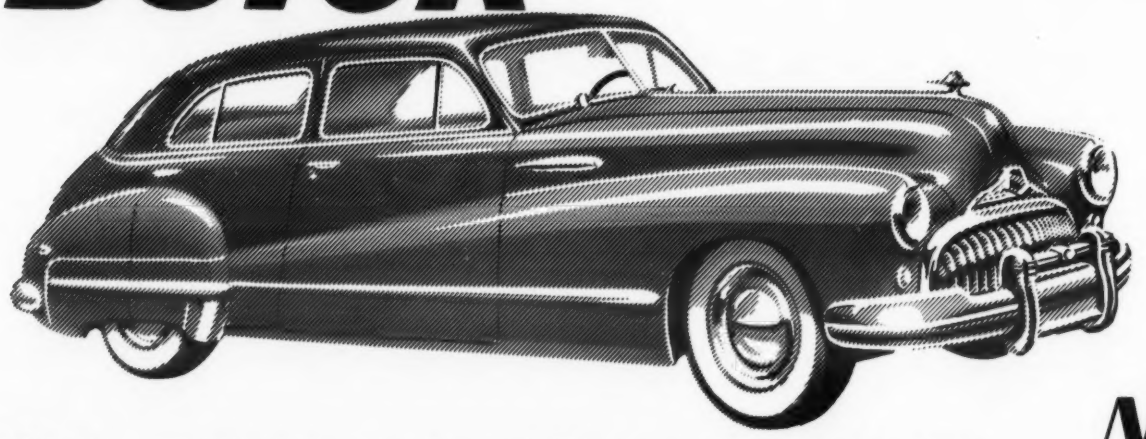

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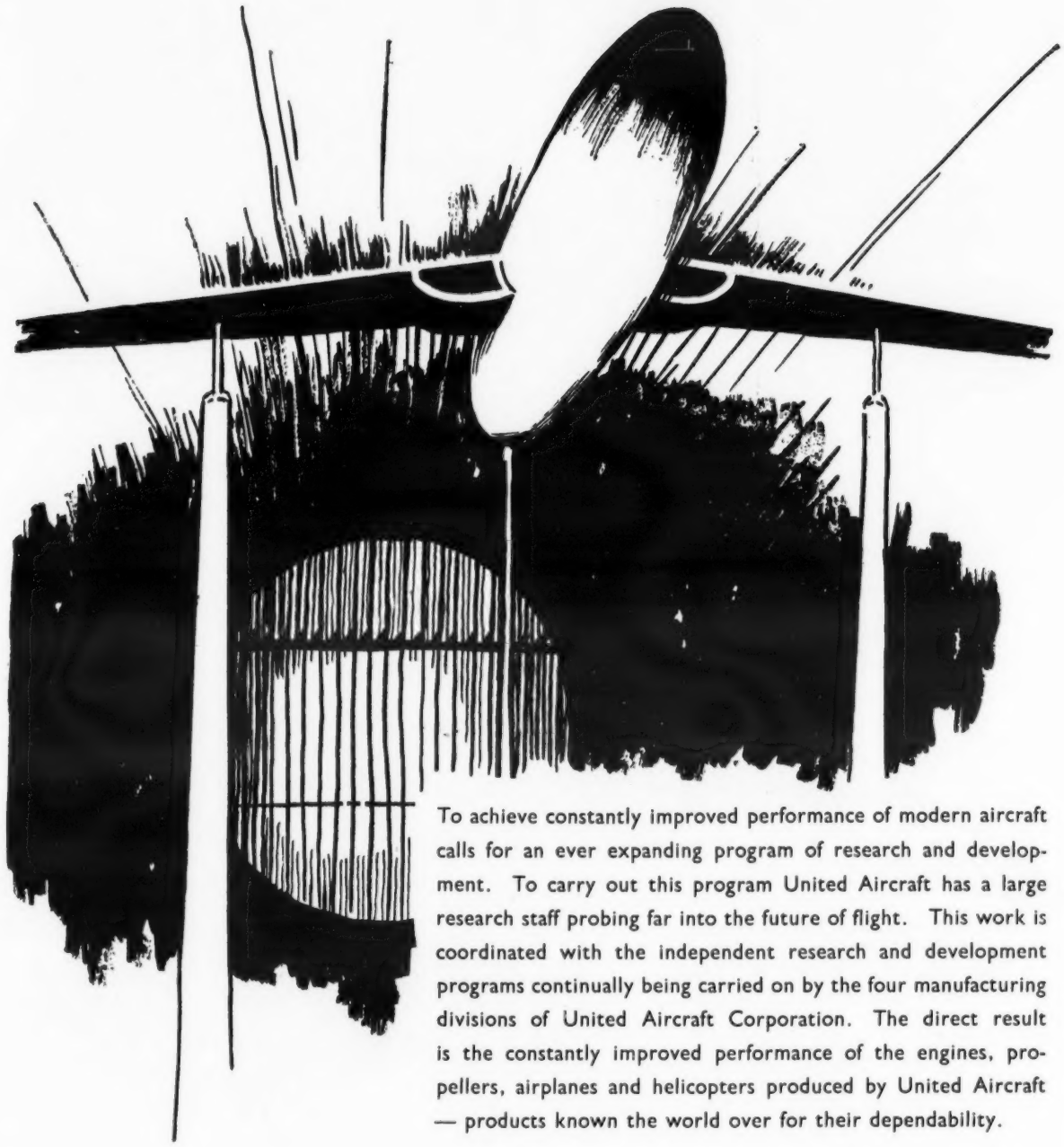

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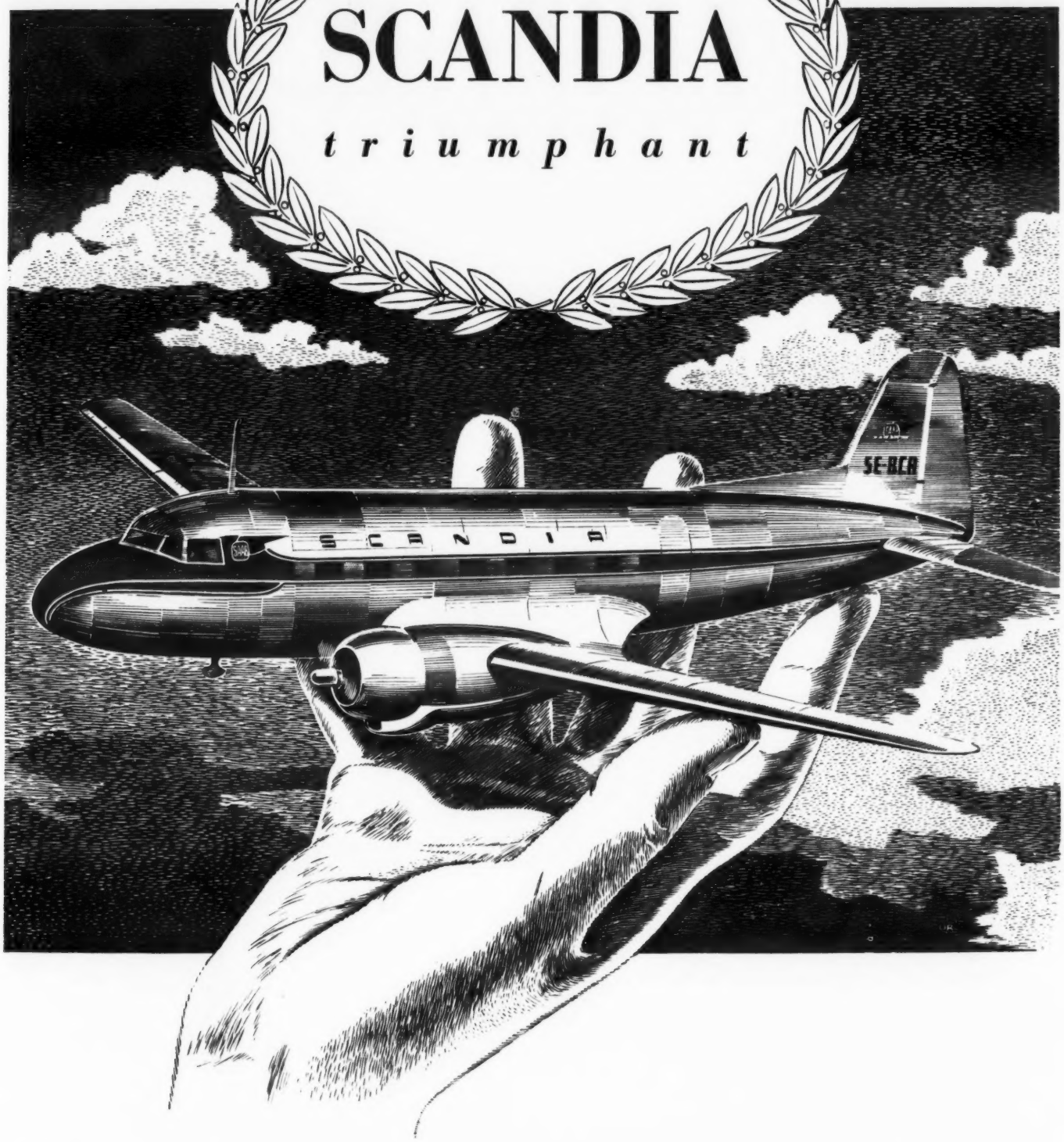

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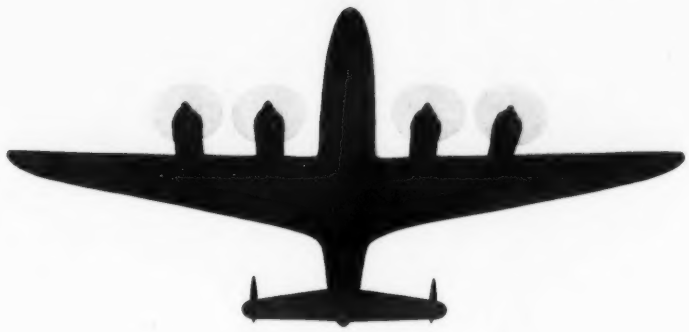

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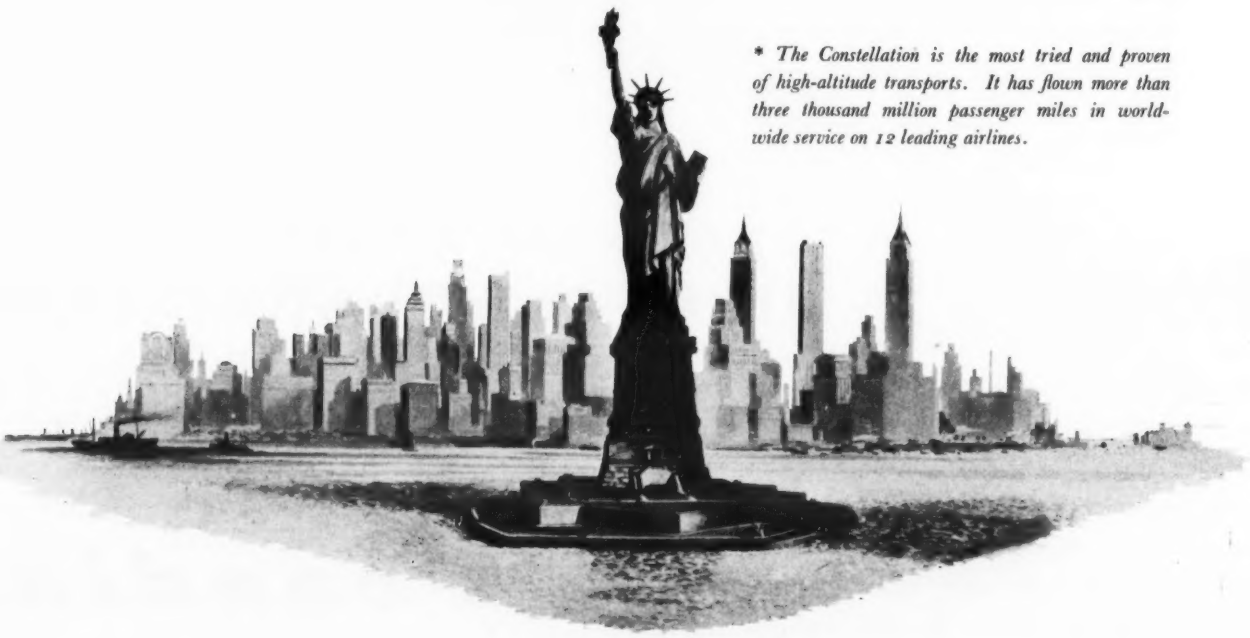

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Marginal Notes

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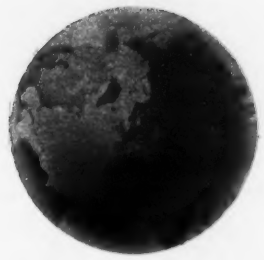


Tired Lion?

Summer 1948 ... Marshall Plan, Berlin air lift, transfer of U.S. Air Force squadrons to air bases in England, new preliminary talks in Moscow. All this does not happen by mere chance ; these occurences form the links of a political chain and will be later read of in history books. The mother of history is geography, as states the author of a recent book of which we shall speak later.

Let us begin with India.

An Empire Air Route becomes International.

The Portuguese were the first foreigners to set foot on Indian soil. This was in 1509. They lost their possession to the Spaniards, who in turn lost to the Dutch ; and the final inheritors were the British. In the middle of the XVIIIth century, the British took up arms to repulse French attacks. The finest jewel of the British Empire seemed to have been won for always.

Under the reign of Queen Victoria, Prime Minister Benjamin ("Dizzy") Disraeli, later Lord Beaconsfield, proclaimed the Indian Empire, in April, 1876. Queen Victoria became the first British sovereign to hold the imperial title, and the British Empire stood at the zenith of its power.

Following World War I, the weakening of the European countries gave rise to a new flaring up of the Indian national movement, and even during the heat of World War II, Winston Churchill had to promise India far-reaching concessions for the post-war period. In February, 1947, his successor as Prime Minister, Clement Atlee, laconically announced the evacuation of India for 1948 at the latest. However, this happened already on August 15th, 1947, and—purely externally—represented the first serious breach in British imperial power.

From the Empire standpoint, it meant that efforts which had guided British politics for two and a half centuries, had become superfluous : the safeguarding of Empire routes by water and by air was no longer the most important order of the day. Beforehand, the establishment of these routes had been the nucleus of everything : in 1704, Gibraltar, gateway to the Western Mediterranean, was taken over ; in 1800, it was the turn of Malta ; and in 1878, as a fruit of the Berlin Congress and the Peace Treaty between Russia and Turkey, Disraeli brought home the island of Cyprus, as a new British stronghold in the Eastern Mediterranean. And shortly before this, in November of 1875, Great Britain succeeded in assuming control of the Suez Canal.

Let us digress a little in order to bring back to memory how British imperial politics used to be conducted. No better picture exists than that painted by the French author, André Maurois, in his biography of Benjamin Disraeli. The Suez Canal bargain was a superb piece of negotiation.

Thanks to one of the usual indiscretions in world history, Disraeli learned on November 15th, 1875, that the Egyptian Khedive was short of money. Against immediate payment of £4,000,000—an enormous sum for those days—the Khedive was willing to pledge his shares in the French-built Suez canal, the sea-road to India. Parliament was not in session, but the Cabinet was convened and Disraeli obtained its approval. Montagu Corry, Disraeli's private secretary, was in the anteroom. "The Chief put his head round the half-opened door, and said one word : 'Yes.' Ten minutes later Corry was in New Court at Rothschild's, whom he found at table. He told him that Disraeli needed four millions on the following day. Rothschild was eating grapes. He took one, spat out the skin, and said : 'What is your security ?'—'The British Government.'—'You shall have it.'"

Would a similar guarantee from Sir Stafford Cripps carry as much weight ?

Meanwhile, to return to Maurois, thus was a "vast Eastern Empire governed, from a hyperborean island, by this stout, self-willed little woman and her old, stooping Minister."

A more epigrammatic example of former British world-power politics is hardly conceivable. At present, the "immense Asiatic Empire of Great Britain" belongs to the past. And in a logical manner, there developed from the sea-route via Gibraltar, Malta, Cyprus, Suez and Aden—everywhere where Great Britain established her naval bases—an Empire aerial route in 1933 : a *Suez Canal of the air.*

Let us take a look at what the London "Times" had to say about this in 1935, thus thirteen years ago :

" ... The Persian Gulf is an area in which England is interested for other reasons than merely that of oil. Along this route extends the aerial highway to India, Australia, even to China soon ; a thoroughfare which in time

British barracks and depots at the foot of the Rock of Gibraltar.

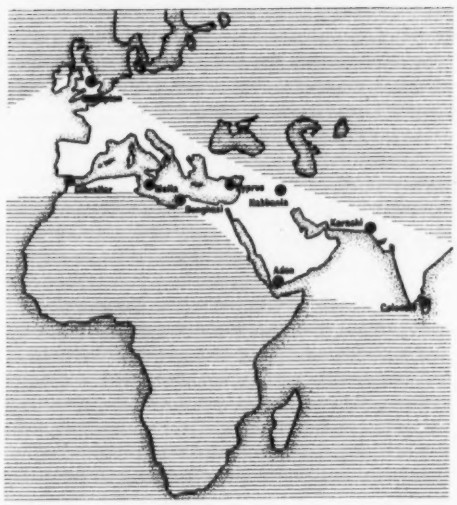
British fighter pilots on Cyprus.

of peace is flown over by Imperial Airways (predecessor of B.O.A.C.—Ed.) and which in case of war will serve to safeguard British Empire communications.

" For Britain, interest is rapidly shifting from the Persian to the Arab coast of the Persian Gulf... At the entrance to the Gulf the Navy had had for over 100 years a post at Basidu, on the extremity of the Persian Island of Qishm, and since early in King George's reign, a station at Hanjam, a tiny island off Qishm. These things sorely vexed the 'embarrassed phantoms' who held office by turns in Teheran . . . Thus a brief announcement was issued a few weeks' ago to say that the British naval posts at Basidu and Hanjam had been closed down, and that a new naval station was being created at Bahrein, on the Arab coast, some 285 miles from Sharjah. This small Bahrein territory, under allegiance to a Sheikh, is modernising rapidly, and after the air and the Navy, the remaining big element in the new Bahrein is the oil . . .

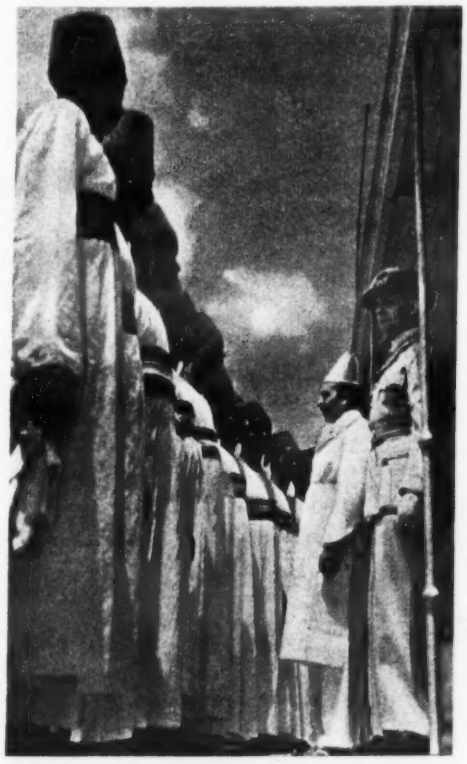
"The Gulf is becoming, as it were, the Suez Canal of the air, an essential channel of communication with India, Singapore, and Australia . . . For a long time no one would believe the legend that there was oil in Bahrein. . . . At last, some five years ago (1930—Ed.), the Californian Oil Company took [the concession] up and formed a subsidiary company, which is now operating. The wells give the most evident signs of the oil about to be struck."

Whether oil would be struck ! Nevertheless in rather a different way than the "Times" had prophesied in 1935. Represented by their oil and aviation concerns, the Americans are today the crown witnesses to the success of the undertaking. The Suez canal of the air, which started as an Empire route, became a real world route. Discovered by the British, it has been well and truly opened up by the Americans.



The Suez Canal of the air.

Empire air route : Egyptian ground personnel of B.O.A.C.



It must be observed that there is a difference between the air politics which Great Britain pursued before the war and those which the U.S.A. is conducting today. Great Britain regarded her air bases as a monopoly, and closed them to others whenever she could. The politics of free trade, which had reached their summit as regards the shipping trade, were abandoned in the Air Age, soon after World War I. Today the Americans are the inheritors of this free trade policy, and conscious of their power, they have no objection if foreign airline companies fly along the same routes as they do. The denser the traffic, the better. It all makes for good business—as regards aviation, oil, and finally the entire American export trade. Hence this Suez canal of the air is today being flown by American, British, Dutch, Egyptian, French, Indian, Italian, South African, and—perhaps tomorrow—by Russian aircraft.

It is here that the threads of world politics form a knot. The West requires its communications with the East. Russia, whose centre of gravity lies in the East, is not yet taking any part in air politics, but has never renounced a window open towards the Persian Gulf... or the Mediterranean area. The Russian standpoint to world affairs has at present more protagonists in Asia than in Western Europe. There, too, on the shores of this Suez Canal of the air, America, whether she wanted to or not, has become the strongest protector of the West. Dollar imperialism ? Nonsense ! . . . The Americans had no alternative.

Monroe Doctrine of Aviation.

The Americans may not be gifted with an overdose of imagination, but no one can deny that they are a logical people.

A country which first threw off the British colonial yoke in 1783, and then in 1823 adopted the Monroe Doctrine of non-intervention in European affairs, will not alter the fundamental principles of its politics as easily as all that : hands off American territory—we do not want to have anything to do with foreign territory !

When the U.S.A. did take a hand in European affairs—the first time in 1917 and the last in 1942—it did not happen voluntarily. America was called in. A patient who spoke the same language urgently required a doctor, a surgeon. The patient was saved, but he still requires to be taken great care of if he is to get well again. There is certainly no doubt that this doctor, after his patient has

fully recovered, would very much like to return to his own family. It is only in this light that one can properly appreciate the Marshall Plan, the Berlin air lift, and the transfer of U.S. Air Force squadrons to Germany, the Mediterranean area, and to Great Britain. A world empire is being liquidated ; the liquidation should proceed without catastrophe . . .

And now to recognise how the non-intervention doctrine devised in 1823 by U.S. President James Monroe is having an unchanged effect even in the Air Age, one does well to recall the Anglo-American air base deal of September 3rd, 1940.

At that time—before America's entry into the war—it was announced from Washington and London that the U.S.A. was presenting Great Britain with fifty destroyers for British supply operations. In return, Great Britain leased to the U.S.A., on a 99-year basis, sites for the erection of numerous naval and air bases, on Newfoundland, the Bermudas, the Bahamas, Jamaica, Santa Lucia, Trinidad, Antiqua, British Guiana, and elsewhere. Delivery of the destroyers represented payment of the lease. Nominally, these areas in the Western Hemisphere are still British possessions. Meanwhile, it requires no extraordinary powers of imagination to prophesy that the U.S. influence on these bases will not be merely temporary. The Americans protected these British colonies during the war ; they supplied them, developed them, and invested capital in various ways. In the year 2039, there may arise the question of whether and under what conditions this lease is to continue.

Monroe Doctrine ! Also Argentina and Chile indicated very clearly in 1948 that they wish to see this doctrine applied in connection with the British possessions in the Antarctic and on the Falkland Islands. And the case of the British colony of Honduras, which was officially acquired after the Monroe Doctrine had been proclaimed, still calls for clarification. Berlin air lift... only this ? Is there not also an American air lift, a series of aerial bridges, over the North and South Atlantic ? And were not the pillars of these bridges erected—under the sign of a Monroe Doctrine of the air—for everyone to see ?

Aerial Bridges.

The first aerial bridges were built directly after the outbreak of World War II by the British, in order to bring American lease-lend aircraft as fast as possible to the European front. When the U.S.A. entered the war in 1942, they showed the world for the first time what "building aerial bridges" really meant. Such bridges were flung across the North and South Atlantic, over the Pacific, towards Africa and Australia. And they worked. The aircraft carriers and the air bases formed the pillars ; directly behind the battle-front was the bridgehead. To this came the fact that the common language of the British and the Americans facilitated the maintenance of air force bases in the Near and Far East, in Africa, in the Mediterranean, in Australia, in New Zealand, and most of all in England.

The Americans came and they went again.

But in the middle of July, 1948, as the international situation showed all the signs of a gathering storm, we learned that the Americans had come back again. On July 17th, squadrons of heavy American bombers once more landed at air bases in England—to fulfil a "short term mission." Fighter aircraft followed. Since these were the aircraft of an old comrade in arms, they were welcome.

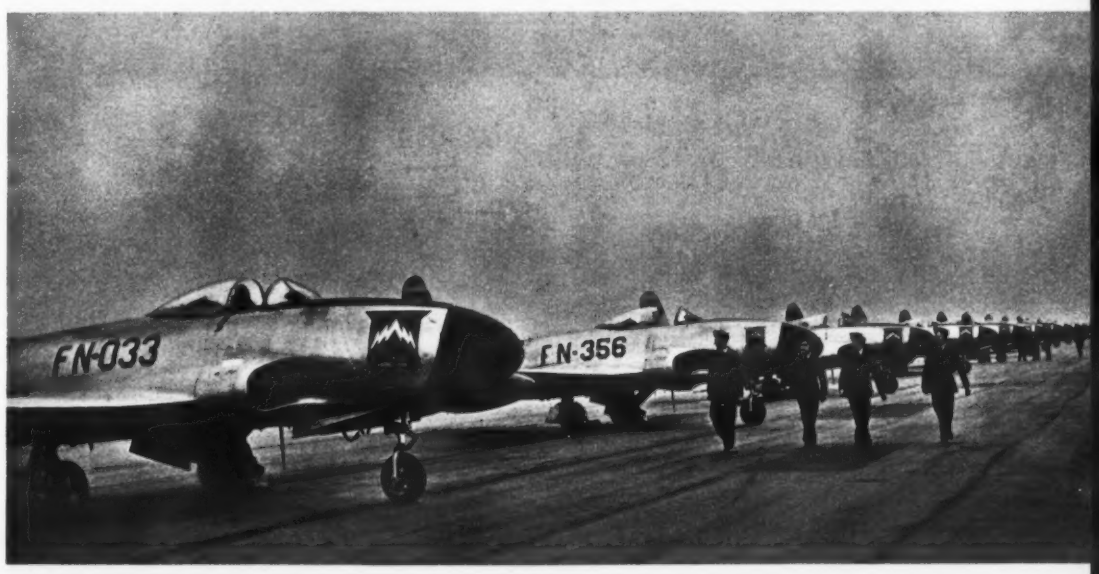
The transfer of these American Air Force units to air bases in a friendly but nevertheless foreign country did not give rise to any great deal of comment, despite the fact that it took place when the world was at peace. The radio and newspapers merely reported on it in the usual manner. The public seemed to find it quite normal that the Americans should send even their own ground personnel to England.

At that time the newspapers were under the spell of the occurrences in Berlin. Eyes were turned to Moscow, where U.S., British and French negotiators are still at this very hour considering with Mr. Molotov as to whether there will have to be a new trial of strength or not. And apart from the Government officials in Washington, Moscow and London, it is probable that very few people gave a thought to what air force manoeuvres in peacetime over foreign territory signified. In that connection, one could have recalled that naval units had beforehand visited foreign naval bases. But manoeuvres ? One had previously not dared to go that far.

Nowadays we have become used to such happenings. One does not become upset if Soviet ground troups and Air Force units travel to the Eastern Zone of Germany, which is not exactly adjacent to the Russian frontier. In the East, too, Russian fliers have to cross Polish or Czechoslovakian territory in order to go between their own and German air bases ; and there is never anything in the way of protest about this.

July 17th, 1948 : Boeing B-29 "Superfortress" bombers of the U.S. Air Force land at Scampton aerodrome, Lincolnshire, England.

U.S.A.F. Lockheed "Shooting Star" jet fighters, having crossed the Atlantic, land at Odiham air station, Hampshire, England.



Let us therefore take matters as they stand : aerial bridges have been put into operation again in all parts of the world, and particularly between the United States, the Continent of Europe, and Great Britain. In order to solve the problem of how long this aerial bridge operation has to continue, and to what it can lead, the Western negotiators are now at work in Moscow.

The Tired Lion.

If there were still a strong British Empire, all these aerial bridges would be British. The very fact that they are primarily American contains a proof that the British Empire is weakening.

The introductory paragraph to this article referred to a book, which endeavours to analyse the political occurences that have led up to this state of affairs. The book is called "After Hitler Stalin ?" by Robert Ingrim, a former Austrian who has now become a U.S. citizien. [1] It would seem that his book is too valuable to become a best seller ; unfortunately it has been obscured by the flood of post-war literature.

Ingrim writes as follows : "It is . . . urgent and most important to destroy a fiction which has been inducing many million people to have an entirely distorted view of the distribution of power on our globe. It is imperative to announce the fact that the British Empire, as far as the Dominions are concerned, is no longer in existence—and I hasten to add that, with a view to world peace, everybody ought to deplore its having been liquidated." Robert Ingrim subsequently describes this liquidation, and further explains how it came about that the Americans had no choice but to intervene in this liquidation with a view to preventing a global catastrophe.

[1] The Bruce Publishing Company, Milwaukee, 1946.

Welcome to England !

The partition of Austria, the promotion of Prussia to a great power, the numerous peace treaties concluded in Europe since the Congress of Vienna, all of which have aggravated the European state of affairs—for each of these happennings, Ingrim attributes a share of the blame to the British. He endeavours to show how Great Britain's efforts to establish a "European balance of power" repeatedly ignited local sparks on the Continent of Europe, which ultimately grew into world bonfires : the Congress of Vienna, which marked the end of the Napoleonic wars ; the aggrandizement of Prussia as a new dam against the East, and its transformation from an Eastern into a Western state ; on the occasion of the Congress of Berlin—the peace treaty between the Russians and the Turks—a political change of policy in the favour of Austria, in order to prevent a dangerous Slav *bloc* from coming into power ; at the first Treaty of Versailles, another political right-about-face and the dismemberment of Austria. And to come to more recent years : in 1925, the Treaty of Locarno as basis for collaboration with the Weimar Republic. But in 1935, suddenly a pact with Herr Hitler, an Anglo-German naval agreement, and thus collaboration with the Third Reich.

Rather than being fastidious, British politics of recent years tended to go where the wind blew. And one of the results of all this was almost to bring together—absolutely contrary to British expectations—the two "supernationalistic partners" Hitler and Stalin.

Describing all this, Ingrim endeavours to prove that the liquidation of the British Empire is inevitable and that the British lion is tired.

Apart from a few tiny scratches, the Empire emerged from World War I more or less unscathed. Its rechristening as the Commonwealth was but a tactful diplomatic gesture. This Empire embraced : the British Isles, the Indian Empire, six Dominions (Eire, Canada, Newfoundland and Labrador, Australia, New Zealand, South Africa), together with fifty-three areas consisting of colonies, protectorates and mandates. After World War II, the Indian Empire dropped out of the Empire union ; a large number of protectorates and mandates in the Middle and Far East have also more or less dropped out ; colonies in the Western Hemisphere may no longer be rightly called absolute British possessions ; the Dominion of Newfoundland recently joined with Canada.

In 1914, England was able to declare war for her Dominions and Colonies, without having to await confirmation by the Dominions. In 1939, however, Great Britain declared war for herself alone ; the Dominion of Canada entered the war a week later, and the attitude of the Union of South Africa was truly hesitant at first.

The diagnosis of Robert Ingrim ? * "...The chief obstacle [to American collaboration with Great Britain] is disappearing. It consisted in an inveterate colonialist resentment against British imperialism . . . Those who advised us from the bottom of their hearts not to participate, fully ignored the rôle of a world power, which cannot be neutral since it must protect its own interests. They overlooked the fact that U.S. neutrality would have led to the definite triumph of the Soviet Union, simply because the latter is at present much stronger than the British Empire. The British Foreign Secretary, Ernest Bevin, has succeeded in manoeuvring the Americans into the front line and withdrawing the British from it..."

This very fact contains the explanation of why British naval and air bases throughout the world had to become the pillars of American aerial bridges—bridges over which streams of American aircraft are flying and will continue to fly, be the world at peace or at war.

E. E. H.

U. S. crew line up at Scampton.

* Taken from "Von Talleyrand zu Molotoff," Ingrim's own translation of "After Hitler Stalin ?", published a year later (Thomas-Verlag, Zurich, 1947) with the last chapter replaced by three new chapters.

A European Union becomes a World Organisation

Preview of the Fourth Annual General Meeting of IATA

A name takes on a meaning.

"You get on my nerves with your confounded aeronautical hieroglyphics," grumbled my exasperated companion. "B. O. A. C., B. E. A. C., A. T. A. A., ICAO, IATA . . . How in heaven's name will it be possible to found new aviation bodies once the various letter combinations have been used up ?" Maybe he thought I was a Job's comforter when I explained that the twenty-six letters of the alphabet can be combined to form about half a million groups of four.

Seriously speaking, of course, a difference can be made between many of these names. Some of them are short-lived, forgotten almost as soon as they are invented. Others become so important and sound so good that even experts are sometimes apt to forget exactly what the letters really represent. One of the best-sounding abbreviations in the domain of aeronautics is certainly formed by the four letters *IATA* — International Air Transport Association — an organisation which will hold its *Fourth Annual General Meeting* from September 14th to 18th, 1948, in the building of the Provincial de Brabant, Brussels.

*

IATA's predecessor, the International Air Traffic Association, which was abbreviated to the same four letters as the present organisation, was born during the inter-war period. Founded at The Hague on August 28th, 1919, it mainly represented an organisation for safeguarding the interest of the European airline operators participating in international civil aviation. Only very few non-European airlines, for instance Pan American Airways, numbered among its members.

The establishment of aerial bridges over the Atlantic between 1927 and 1939, coupled with the meteoric development of aircraft construction during World War II, revealed the inadequacy of this pre-war organisation of regional character. The war had not ended before, in 1944, the nations conferred at governmental level in Chicago and established the Provisional International Civil Aviation Organisation, PICAO, which has since discarded its provisional nature and become ICAO. And during the same war year, the idea arose to re-organise the old IATA on a world-wide basis. The IATA President at that time, Professor Daniel Goedhuis, the well-known Dutch expert on air law, and the President of the Air Transport Association of America, Colonel Edgar S. Gorrell, asked the airline operators present in Chicago to attend preliminary talks : the result was to be the present-day IATA. The foundation meeting took place in April, 1945, in Havana, when airline companies from thirty-nine countries were represented. The IATA roster now contains the names of seventy companies in all parts of the world, and eight more companies, which recently joined the Association, will also be represented at this year's General Meeting.

Why IATA grew.

Sir William P. Hildred, Director-General of IATA, has a knack of avoiding long-winded definitions and is positively allergic to anything unnecessarily complicated. He once defined IATA's working principle with the words : "We must streamline our commercial procedures and keep paperwork to a flexible minimum."

Constitutionally, IATA is an commercial union of private operators, formed in order to protect the interests of its members. In practice, however, it has long outgrown its original purpose. Foremost among its efforts is service to airline passengers, freight shippers, and the technical and organisational development of world aviation.

IATA streamlined.

Legally speaking, the International Air Transport Association is officially registered as a Canadian company, with its head office in Montreal. It has a General Meeting, an Executive Committee, an Honorary President, a Permanent Director-General and Secretary-General, the Central Administration in Montreal being responsible to the two latter officials. The Association remains in constant contact with practical airline operations through four standing Committees (Financial, Legal, Technical and Traffic) and three Regional Traffic Conferences (1 : North and South America, Greenland, Bermuda, West Indies, Hawaii, Midway and Palmyra Islands ; 2 : Europe, Iceland, Azores, Africa, Ascension Island, Asia west of and including Iran ; 3 : rest of Asia, Australia, New Zealand, Pacific Islands not included in the first region). In these bodies are represented the best experts the airlines can find, and a system provides for their being made available a few times each year for IATA meetings. As Sir William Hildred puts it : "IATA does not hold to the popular fallacy . . . that an expert can be kept away from his work for months and years at a time, and still remain an expert."

Achievements and aims.

The notes which follow will highlight only a few of the major achievements of IATA.

One of the most successful creations of the *Financial Committee* was the IATA Clearing House, in London (cf. "Interavia Review," No. 10, Vol. II), which is rendering inestimable service to the airlines. During the first complete year of business, 1947, clearances totalled $52,400,000, whereby cash payments were kept down to $9,600,000. During the devaluation of the French franc, the creditor companies were preserved from losses, and the debtor companies alleviated in every possible way.

The *Technical Committee* took an active part in ICAO's work. At the Technical Conference at Nice alone, in September, 1947, it submitted 105 recommendations to ICAO. Working with the International Telecommunications Union, this Committee succeeded in having exclusive wavelengths established for aviation purposes, and also in having them registered internationally.

Less spectacular but just as successful results have been achieved by the Traffic Committee and its sub-committees : the standardisation and simplification of general conditions of carriage, the international regulation of ticket agency procedures, the simplification of the various forms and formalities, the adjustment of tariffs, and so forth. The publication of an official IATA Air Guide is also thanks to the initiative of the Traffic Committee.

*

The agenda for the Fourth Annual General Meeting features such topics as charter operations by scheduled airlines, arrangments for the carriage of immigrants and displaced persons, further standardisation and simplification of airline practices and procedures throughout the world, international conventions affecting air transport, insurance matters, and the operations of the IATA Clearing House at London.

Various international organisations have been invited to send observers, among others ICAO and UNO. It is unofficially announced that Yugoslav, Russo-Hungarian and Russo-Roumanian observers will also attend the Brussels meeting. Thus it may be seen that, provided the world remains at peace, IATA, once a European union, will finally expand to embrace all countries of the world.

"All right ; now let's see you fly it !" Author at the controls of the "flying test stand." In light coat and wearing dark glasses is Stanley Hiller Jr.

... and it comes out here

BY SCHOLER BANGS, LOS ANGELES

By the time you read this, 23-year-old Stanley Hiller, Jr., of Palo Alto, California, probably will have gained his Approved Type Certificate for what he claims is the "world's first inherently stable helicopter."

That his claim is valid, I can attest.

I know of no other helicopter designer who would have had the temerity, the audacity, to give me exactly eight minutes of ground instruction on the controls of his machine and then step back and with an upward flick of his thumb say :

"All right ; now let's see you fly it !"

Eight minutes earlier I had never before had my hands on the controls of any helicopter.

Yet here I was, only six feet off the ground to be sure, but soloing ; essaying a slight turn to bring into vision the wind cone on the hangar roof ; gently nudging the control stick with my fingertips to correct for wind drift.

Up and down for five brief hovering flights within the space of half an hour.

On the last flight just giving way to the sheer enjoyment of sitting there . . . skinny, dumb and happy . . . until a shout from below told me I was drifting from the landing circle.

Suddenly the control column before me was terribly important.

Just as suddenly I realised that stick before my eyes was bare, naked — NO HANDS !

I had been sitting serenely with my hands in my lap !

Mr. Hiller's helicopter had been doing the hovering of Mr. Hiller's helicopter !

A mechanic tugs at the landing gear as Chief Pilot Frank Peterson demonstrates the inherent stability.

Why hadn't it started to "pendulum" ; to dive ; or to roll over on one side ?

To young Mr. Hiller the explanation was astonishingly simple :

"Because it is inherently stable ; the result of our servo-rotor control system — the little paddle rotor blades set at ninety degrees to the two main lifting blades."

Patiently he explained the mechanics of the system, and then had his chief pilot, Frank Peterson, go up to demonstrate.

A few feet above the ground Peterson hovered, and then took his hands from the control column as a mechanic stepped up and gave a might tug at one of the wheels of the landing gear.

The little 'copter, which was the "flying test stand" prototype of the commercial "Hiller 360" now completing its Civil Aeronautics Administration tests, swung violently as the wheel was released.

One . . . two . . . three decreasing swings, and the helicopter again was hovering motionless in the air, Peterson's hands still outstretched from the control column.

But, why ?

Because of the notorious instability of rotary wing craft, which conventionally demand that the pilot be "on" the controls constantly to catch incipient rolls or dives, I wanted a specific explanation.

Hiller, Peterson, and a small cordon of engineers and mechanics attempted to give me aerodynamic reasons why.

"Mr. Hiller's helicopter flies Mr. Hiller's helicopter." The pilot is replaced by sandbags.

Joseph Stuart, III, project engineer for the "360," hustled me into his office and said it with equations.

I protested.

"But I'm not an engineer ! Can't you just describe it in words ?"

Stuart, baffled, tapped his pencil on the paper before him.

"It's all wrapped up in engineering formulae. You really have to see the equations to understand it."

This happens. That develops. The result comes out this way.

It was strongly reminiscent of the catchy, silly little pre-war song of the cornet player explaining how he does it :

"Oh, the music goes 'round and 'round . . . dum dah dee dah . . . and it comes out here !"

Since then, however, after three successive trips from my home in Southern California to Hiller's United Helicopters, Inc. plant at Palo Alto, I have come to a fairly accurate impression of just what happens, and Hiller has been able to condense it into three written paragraphs.

But, first, let's have a look at the mechanics of his stability producing system.

Actually, Hiller didn't have the faintest idea, at the outset, that he was heading toward inherent stability when he began work on the design.

He had been committed, at the inception of United Helicopters, Inc., two years ago, to initial production of three experimental co-axial helicopters, the "Commuter" design which many believe would become a commercial offering.

However, he could foresee the complexity of production and maintenance which would pertain to the large number of working parts required for the two-rotor co-axial system.

Secretly he worked on a small single-rotor machine having a simplified control system of only seven component parts.

During a test flight, after having risen only a few inches, the new helicopter rolled over on its side before the pilot could begin to counter-control.

Hiller and his engineers felt that they really had something in the simplified mechanics of the new control.

But a more positive control was mandatory if they were to overcome the hazards of instability.

One of Hiller's engineers recalled early experiments with aerodynamic paddles, which they had conducted with the idea of boosting control forces in changing the cyclic pitch of rotor blades.

The little flying test stand was rebuilt, and its two-blade rotor attached to a universal hub on the driving shaft. At ninety degrees to the main blades the hub carried small paddle blades. The pilot would not control directly the positioning of the rotor disc. He simply would control, through a transfer bearing, a cyclic positioning of the paddles. They, through their changing of position in rotation, would exert forces upon the hub that would vary the attitude of the rotor disc.

The control which resulted was everything that Hiller had hoped for.

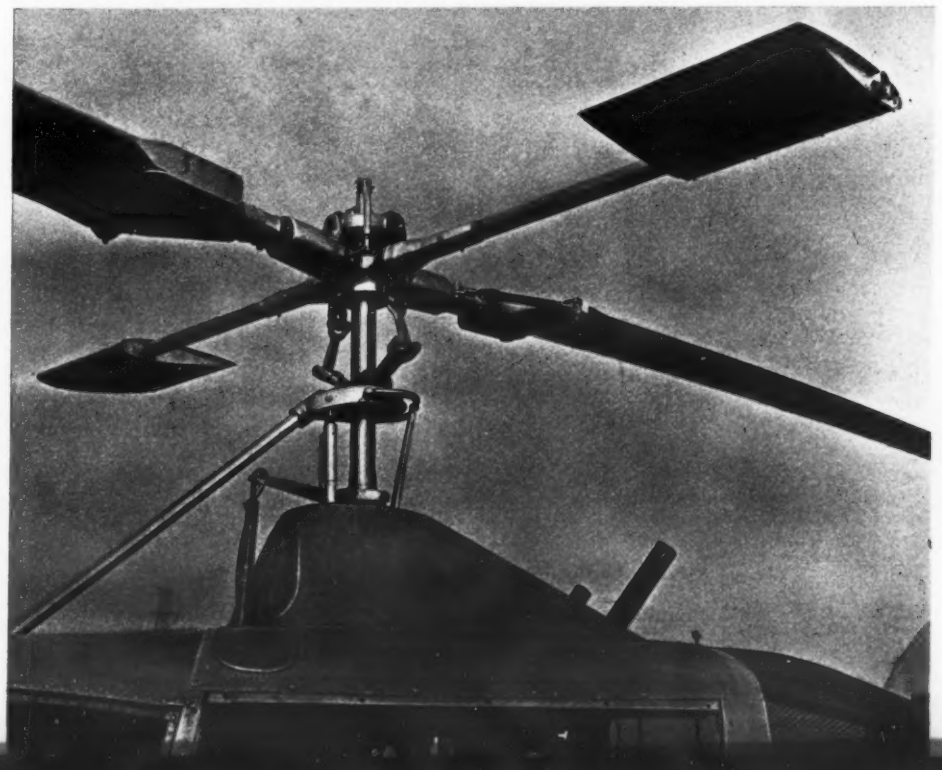
And more . . .

Peterson on his first flight hovered above the excited group and calmly reached both hands into his pockets for a package of cigarettes and a lighter, and proceeded to enjoy both cigarette and the startled faces beneath him before resuming control, and descending.

Says Hiller : "It was hard to believe, at first. But there it was. We had hit upon the one simple device that would give us inherent stability."

The results of the system are truly phenomenal, for while it offers the combination of positive control and stability, the effectiveness of the system can be varied to meet the particular requirements of a given helicopter to which it is applied.

Inherent stability control system of "Hiller 360." Pilot's control column passes through cabin roof to transfer bearing to impart cyclic positioning to small servo rotor blades. Their aerodynamic force changes disc attitude of main rotors, mounted universally on driving shaft. Only control imparted by pilot directly to main lifting blades is uniform pitch change for rising and descending.



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Commercial version of "Hiller 360" demonstrating its utility for power line inspection.

Here's an example. The servo rotor blades on the "flying test stand," which I hovered after eight minutes of instruction, were of such size and distance from the hub that the system displayed appreciable control lag. A gentle push on the control column would initiate a quick response of the helicopter towards the direction of the stick's movement. Yet, a violent shove of the stick in one direction, and return to centre, would bring no response from the helicopter. It was if it politely chose to "forget" that I had committed the sin of violent over-control.

However, by varying the size and position of the servo blades, the lag time can be reduced to give a helicopter having a more responsive, or sensitive, touch.

Beginners, or private pilots, probably will find the "forgetful" adjustment most satisfactory.

Commercial or military helicopter pilots doubtless will speak for the more sensitive.

Hiller's "360" commercial model has control response considerably above that of the test prototype.

In my most recent call at his factory he invited me to fly with him.

Cruising at five hundred feet we easily overtook a Cub, circling to approach its nearby airpark, and after a sharp turn away from the airplane traffic pattern Hiller levelled off and folded his arms after trimming the machine for forward hands-off flight.

What gave it this stability ?

Hiller at last had the answer — in words :

"Compared with the lifting rotor, the control rotor has low aspect ratio airfoils and a much smaller span. These factors together cause the control rotor to be very much more sluggish than the lifting rotor.

"The sluggishness of the control rotor causes any motion of the aircraft body, not called for by the pilot, to be very highly damped by the lagging rotor system. In this manner several times the normal damping value is made available.

"Good control response still is, of course, a 'must.' It is provided by the incorporation of 'control input multiplication,' multiplying the cyclic pitch input to the control rotor 2.5 times. This causes the normally sluggish control rotor to respond with the alacrity desired, giving the pilot a sensitive yet highly damped control. The phenomenal stability is a happy byproduct of an intersection of the sluggish control rotor and the rapidly responding lifting rotor."

Avro's Chief Test Pilot, J.H. Orrell, about to take the "Athena 1" off on its first flight.

Balliol Athena

Two British Advanced Trainers

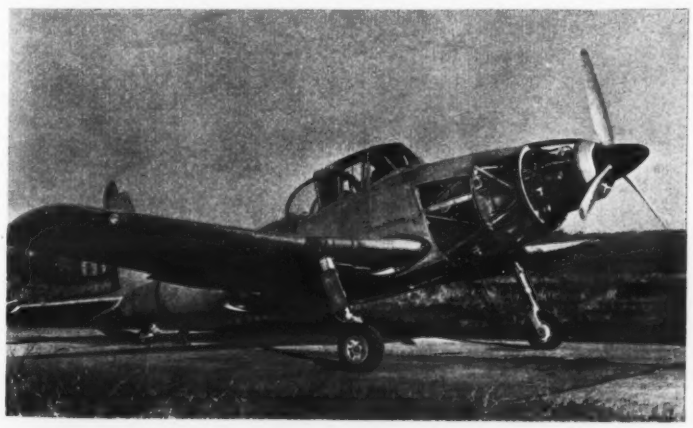
Royal Air Force training methods now make extensive use of three-seater aircraft for basic and advanced training. Even the Percival "Prentice," powered by a de Havilland "Gipsy Queen" of 250-300 H.P. and fitted with a fixed undercarriage, which can be used for both phases of training, has three seats. In such aircraft, pupils are able to learn both from their own mistakes and those of co-pupils. Besides this, a three-seater aircraft also enables a wireless operator to be carried and trained together with the pilots in flying under various weather conditions, without placing an extra burden on the National Treasury.

Two new advanced training aircraft developed on the basis of Air Ministry specifications issued in 1945—the *"Balliol"* of Boulton-Paul Aircraft Ltd., of Wolverhampton, and the *"Athena"* of A.V. Roe & Co., Ltd., Manchester—are also three-seaters. They are similar to each other, not only in general, but also as regards many details: they have approximately the same gross weight, wing area, and are powered by the same types of engine. The chief novelty of both types is that they incorporate the first application of propeller-turbines to training aircraft—in fact the first use of such engines in single-engined aircraft at all. Meanwhile, versions have been prepared of both aircraft with conventional piston engines, thus enabling them to be compared from the standpoints of flight characteristics and economy, and making it possible to collect valuable operational data.

The "Balliol I" and "Athena I" are powered with Armstrong-Siddeley "Mamba" propeller-turbines, which will ultimately deliver about 1,270 H.P. at the take-off, and approximately 1,520 H.P. peak output at maximum speed. The conventional "Balliol 2" and "Athena 2" models have Rolls-Royce "Merlin 35" liquid-cooled twelve-cylinder in-lines of 1,280 H.P. take-off power. All four prototypes have accomplished successful first flights during recent months. A "Balliol" version designated P. 108, which has all the features of the turbine version except that it is powered by a 1,000-H.P. Bristol "Mercury" air-cooled radial, was demonstrated in the air at last year's S.B.A.C. Show at Radlett.

The intention was to use these two aircraft for continuing the training of pilots who have already terminated their basic training in the "Prentice." Between the speed range of the latter aircraft (56-150 m.p.h.) and that of a low-attack aircraft, a single seater fighter or a modern jet fighter, there is a big difference; and to overcome this it is imperative that pilots should gain experience with advanced trainers. In addition, the working of such items as the undercarriage, dive brakes, boost pressure regulation, propeller pitch adjustment, is far more complicated in combat aircraft, and the many manipulations demanded of the pilot must be practised over and over again. The transition to jet aircraft requires really serious preparations, since these

Boulton Paul "Balliol 1." The cowling has been removed to reveal the installation of the "Mamba" propeller-turbine. Aft of the wing is the jet outlet.



One of the most noticeable differences between the Avro "Athena 1" and the Boulton Paul "Balliol 1" is the configuration of the tail assembly.

present the additional difficulty of the great sensitivity of turbo-jet engines to servicing errors.

The "Mamba"-powered "Balliol 1" and "Athena 1," by the time their development trials had been completed, will presumably provide many of the characteristics at present lacking in aircraft used for such transitional training purposes. Whereas propeller-turbines have many particularities in common with turbo-jet engines, they also offer—primarily during take-offs and sudden gains of power—superior manoeuvrability because of the propeller. It therefore seems right to surmise that they will be extremely suitable for this transitional training phase.

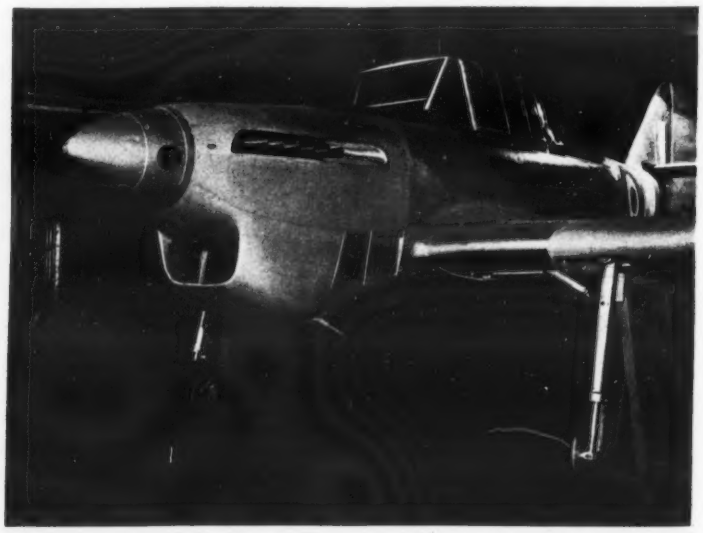
The versions powered by the "Merlin 35" engine naturally enable a major portion of the training programme to be carried out with conventional aircraft. They are being produced and will be in service before the turbine versions have completed their development trials. Apart from this, noteworthy economies are effected, since the price of turbines is still twice as high as that of piston engines delivering the same power. It is worth noticing that the maximum speed of the "Athena" (287 m.p.h.) and the "Balliol" (300 m.p.h.) remains the same when the engines are changed about; merely the cruising speed is lower in the piston-engine version, since the latter has to be throttled down more than a turbine. Stalling speed, climb performance, ceiling, take-off and landing runs are roughly the same. This circumstance is likely to be especially valuable in the transitional training from piston-engined aircraft to turbine types, notably since this can be carried out with the same airframe.

Aircraft	Boulton Paul Aircraft, Ltd.		A. V. Roe & Co., Ltd.	
	"Balliol 1"	"Balliol 2"	"Athena 1"	"Athena 2"
Power plant	Armstrong Siddeley "Mamba" 3-blade propeller 10 ft.	Rolls-Royce "Merlin 35" 4-blade propeller 11 ft. 3 in.	Armstrong Siddeley "Mamba" 3-blade propeller 9 ft. 6 in.	Rolls-Royce "Merlin 35" 4-blade propeller 10 ft. 9 in.
Take-off power	1,270 H.P. (15,000 r.p.m.)	1,280 H.P. (3,000 r.p.m.)	1,270 H.P. (15,000 r.p.m.)	1,280 H.P. (3,000 r.p.m.)
Maximum continuous power *	1,060 H.P. (14,000 r.p.m.)	1,060 H.P. (2,650 r.p.m.)	1,160 H.P. (14,000 r.p.m.)	1,060 H.P. (2,650 r.p.m.)
Span	39'4"	39'4"	40'0"	40'0"
Length	36'6"	35'1½"	36'6"	36'6"
Wing area	250 sq. ft.	250 sq. ft.	270 sq. ft.	270 sq. ft.
Tailplane and elevator area	51.4 sq. ft.	52.8 sq. ft.	74.2 sq. ft.	74.2 sq. ft.
Fin and rudder area	25.3 sq. ft.	24.2 sq. ft.	30 sq. ft.	30 sq. ft.
Undercarriage track	15'0"	15'0"	12.2'	12.2'
Gross weight *	7,845 lbs.	8,310 lbs.	7,680 lbs.	8,340 lbs.
Empty weight, fixed equipment and oil *	5,750 lbs.	6,685 lbs.	5,500 lbs.	6,650 lbs.
Fuel	1,370 lbs.	910 lbs.	1,460 lbs.	970 lbs.
Crew and removable equipment *	726 lbs.	725 lbs.	720 lbs.	720 lbs.
Wing loading	31.4 lb./sq. ft.	33.2 lb./sq. ft.	27.4 lb./sq. ft.	30.9 lb./sq. ft.
Take-off power loading	6.2 lb./H.P.	6.5 lb./H.P.	6 lb./sq. ft.	6.5 lb./sq. ft.
Ratio of wing loading to power loading	5.1 H.P./sq. ft.	5.1 H.P./sq. ft.	4.7 H.P./sq. ft.	4.7 H.P./sq. ft.
Maximum speed at 10,000 ft. *	300 m.p.h.	300 m.p.h.	287 m.p.h.	287 m.p.h.
Maximum continuous cruising speed at 10,000 ft.	269 m.p.h.	240 m.p.h.	253 m.p.h.	223 m.p.h.
Stalling speed with flaps	—	—	81 m.p.h.	81 m.p.h.
Diving speed with dive brakes	350 m.p.h.	350 m.p.h.	325 m.p.h.	345 m.p.h.
Rate of climb at sea-level	36.7 ft./sec.	34.1 ft./sec.	40.7 ft./sec.	34.1 ft./sec.
Ceiling at full gross weight *	38,000 ft.	34,000 ft.	34,000 ft.	30,000 ft.
Take-off distance to clear 50 ft. *	510 yds.	450 yds.	600 yds.	750 yds.
Landing distance to clear 50 ft. *	650 yds.	650 yds.	550 yds.	740 yds.
Endurance (10,000 ft. at max. continuous cruising speed) *	2 hr. 30 min.	2 hr. 30 min.	2 hr. 40 min.	2 hr. 40 min.

*) Estimated data.

Boulton Paul "Balliol 2" powered by a Rolls-Royce "Merlin 35" reciprocating engine. Note the new shape of the cockpit canopy.

In the "Athena 2," likewise powered by a "Merlin 35," the wing is positioned further forwards along the fuselage than in the "Athena 1."



Examination of the table pertaining to all four versions reveals the noticeably high empty weight of the piston engine version compared with the turbine model ; this is however partially offset by the reduced fuel consumption of the piston engine. The estimated data given in the table are subject to revision during the development trials, whereby it is likely that the "Balliol" and "Athena" values will approach each other more closely.

It is natural that such advanced trainers are expected to reveal flight characteristics approaching those of single-seater fighters. Both types therefore have very large control and stabilising surfaces. Then, a central positioning of the fuel tanks in the wing centre section and the retraction of the main undercarriage wheels in an upwards and inwards direction keeps the aircraft's inertia moments small. Large dive brakes give rapid deceleration to the diving speed.

Let us first note the structural features common to both types. Both are of all-metal construction ; even the rudders are mefal covered. The wings are of two-spar, stressed-skin design, the fuselage being reinforced monocoque. All control movements are transmitted by light alloy rods ; undercarriage retraction and actuation of the flaps, dive brakes and wheel brakes is all pneumatic.

Both types have roomy cockpits. There are two pilot seats side by side in front, with dual controls and duplicated engine controls. The space behind these seats is either for an additional pupil or—especially in the heavier piston-engined version—for additional equipment. The cockpit canopy can be slid back electrically and jettisoned in case of an emergency. It may be noted that the fixed rear part of the canopy, which is still a little shapeless in the "Balliol 1," will be streamlined in later versions.

For application of the R.A.F. Synthetic Day-Night Flying training method, in which the pupil wears coloured goggles, the windscreen can be covered by an amber filter so that the complement of colours gives the pupil the illusion of night. Even this amber filter is actuated pneumatically.

Finally, there are regulators for cabin ventilation, heating, and oxygen breathing.

The instrumentation, wireless equipment and military items are especially varied in order that the same aircraft can be used for as many training purposes as possible. In addition to complete blind-flying equipment, there is also a gyrosyn compass.

The radio equipment comprises a VHF transmitter-receiver, a TBA (tunable beam) receiver and an IFF recognition signaller.

For gunnery practice, each aircraft has a Browning machine gun of 0.303 inch calibre and a camera gun built into the wing centre section. Gyro gun sights are positioned before each front seat. Practice bombs, aerial cameras or two auxiliary fuel tanks can be carried beneath the wing.

As regards the differences between the "Balliol" and the "Athena," the first thing one notices is the different configuration of the tail assembly. The two halves of the tailplane, and the fin, of the "Balliol" are attached to the conical rear portion of the fuselage and are interchangeable ; the rudder is located further forwards than the elevator. In the "Athena," however, the fin forms a unit with the fuselage and features an opening through which the single-section tailplane and elevator protrude ; the latter is consequently located further forwards than the rudder. For target or glider towing, the cable attaches directly to the point of the rear fuselage of the "Balliol," whereas there is a special attachment beneath the fin of the "Athena" for this purpose.

The wing of the "Balliol" has a somewhat smaller span than that of the "Athena," is built up of four sections, and can be folded upwards to economise storage space. The wing centre section of the "Athena," on the other hand, is in one section, and the outer panels cannot be folded. The "Balliol" has its dive brakes above and below the wing leading edge, whereas the "Athena" has them on the trailing edge of the wing, pivotable about their centre lines. The outboard flaps on the "Athena" therefore pivot on the same axis as the dive brakes and can of course only be deflected when the dive brakes are up.

Above : Avro "Athena 1." Below : Boulton Paul "Balliol 1" taking off.

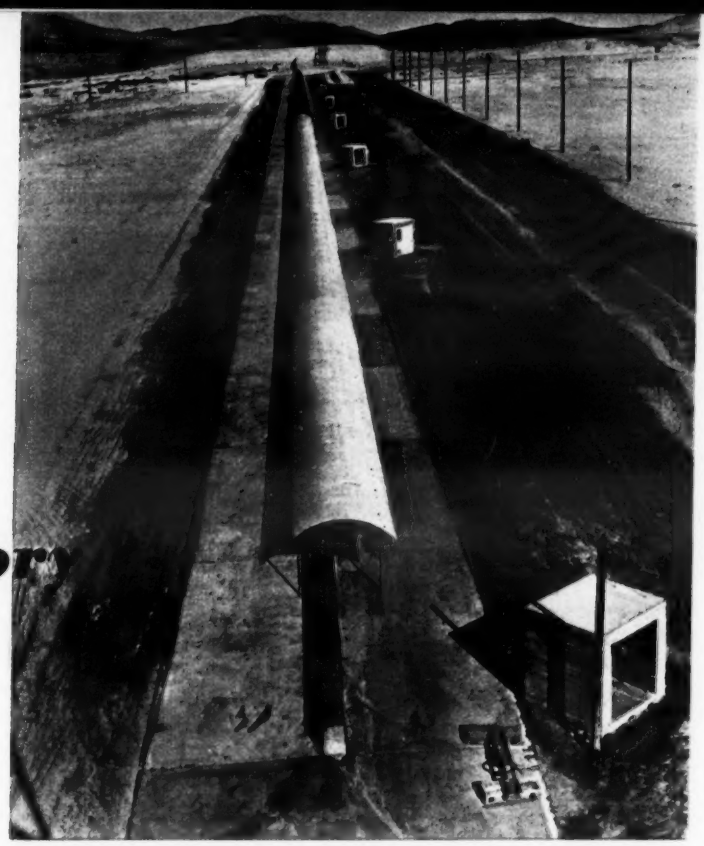
All control surfaces of the "Athena" are actuated by spring tabs, which in turn are connected with the main surfaces by torsion rods. The control surfaces of the "Balliol" are operated directly by the pilot and carry trimming tabs which are adjustable from the cockpit.

In the case of both aircraft, the greater weight of the "Merlin" engine gives rise to certain differences in connection with the position of the centre of gravity. To take the "Merlin," the fuselage nose of the "Balliol" had to be shortened by a section of the engine mount, whereas in the "Athena 2" the wing had to be positioned about 27 inches further forwards than in the "Athena 1." Apart from this and the different engine installation, all other main components of the "Athena 1" and "Athena 2" are interchangeable.

A few details of the "Mamba" installation are discernible from the photo of the "Balliol 1" on page 549. Passing through the annular fire wall, the exhaust conduit of the turbine is at first of round and, further aft, of oval cross-section, finally leading to the jet outlet beneath the wing. This arrangement of the exhaust, which is the same in both aircraft, eliminates the power losses occurring in designs with bifurcation or sharp deflection of the jet pipe. Furthermore, the starboard-side outlet position eliminates the possibility of injury to the sailor releasing the arrester hook during carrier operations.

It may strike one as peculiar that such fast and modern advanced trainers as the two types mentioned above, contrary to all present jet fighters, are not equipped with a nose-wheel undercarriage. Meanwhile, if one considers that the other aircraft of the R.A.F. feature tail-wheel undercarriages, it seems right that a particularly versatile design of trainer aircraft should also enable pupils to acquaint themselves with all the difficulties of all the conventional landing procedure.

Luna ... U. S. Territory



Test range for guided missiles at the U.S. Naval Ordnance Test Centre, Inyokern, Mojave Desert.

It was one of those typical aircraft factory supervisors' dinners, where conversation flows freely and sometimes up to the very borderline of discretion.

This one was in Southern California, and one of the company's guests was a shade put out at having been seated next to a dark-haired, serious youth who at best was still in his early twenties.

You would have thought the occasion justified his being seated, at the very least, beside the company's chief engineer or even the president.

Oh, well ! He would make the best of it.

Conversation literally boxed the compass, and veered from wartime achievement to rockets ; turbo-jets to propeller maximums; the flights of the XS-1 to theoretical ultrasonics.

Quite distressingly complex to a layman ; but it did point to an opening for an attempt at polite, if patronizing, conversation with the youth :

"Do you think that in our time anyone actually will fly to the moon ?"

The youngster's fork paused, and there was a moment of what seemed to be startled concentration before he turned and told his elbow companion with casual assurance :

A Grumman F6F "Hellcat" carrier-borne fighter releases a rocket missile over Inyokern.

"Yes. I will do it."

Dinner Guest gulped.

Not only had his good friend, the company president, seated him beside a mere boy, but a mad lad as well !

Both, man and youth, had been under a cloud of misunderstanding.

The youth, no doubt, had assumed that Dinner Guest, invited to so select a banquet, was at the least a fringe member of "the team" and cognizant of what his company was doing. Otherwise he would have parried such a question with a degree of finesse.

Dinner Guest, on the other hand, most certainly would have pressed for an elaboration, ravagingly curious, had he but known that the youth was a lead scientist in the company's very, very hush and mysterious "division of astrophysics."

Security discretion prevents specific identification of the company.

It might have been Douglas, Ryan, Convair, Lockheed, North American, or Northrop.

It is no secret that all, and in fact every one of the aircraft manufacturers in the United States is engaged in one or another phase of developing, under national defence appropriations, very long-range guided missiles.

Significantly, within the past few months the United States has lifted its own "iron curtain" just enough to disclose a hint of the progress of rocket research since the end of the war.

To reveal a "big stick" to Russian eyes ?

Perhaps.

Fairchild has been permitted to publicise its activity in nuclear engine research ; to describe roughly the small atomic reactor closed-circuit boilers which reasonably could power aircraft turbo-jet, ram-jet, and rocket engines by a heat transfer process. Engineers of this company have indicated that nuclear power plants are within reach for aircraft of the weight of the B-36 and larger.

At early-established proving grounds, such as White Sands, new rocket shapes are being tested constantly in small experimental sounding units which show efficiencies vastly exceeding that of the V-2.

A western university shortly will announce its construction of a wind tunnel designed to test fairly large models of high-speed shapes at Mach 10.

Testing of new rocket fuels has gone far beyond the limitation of conventional safety, and proving grounds are being set up in isolated mountain areas to attempt the "taming" of compounds which may become the self-sufficient propellants of tomorrow's long-range rockets, or be used in conjunction with atomic reactor systems.

The recent announcement, at a March Field Air Base navigation conference, of research aimed at astrophysical mid-course guidance of long-range rockets was impressive, and pointed to automatic navigation by having a rocket's flight control mechanism actuated by electro-optic determination of course position with relation to two or more pre-determined stars.

How soon these elements of outer space flight—nuclear and chemical power, and automatic celestial navigation — will be put to actual test is conjectural.

One might incline strongly towards an assumption of "not long" in piecing together the reports of intensive expansion of U. S. testing centres.

Initial appropriations, now approved, are starting a $50,000,000 development of a Navy Air Missile Test Centre at Point Mugu, on the Pacific Coast not far from Los Angeles. From this point missiles could be launched for flights of several thousand miles across the Pacific.

One of the most complete multi-million dollar research laboratories in the world has just opened for business at the U. S. Naval Ordnance Test Centre at Inyokern, at the northern end of the Mojave Desert.

It is true that much of the publicised activity at Inyokern revolves around the testing of the highly conventional ; the launching and testing of wartime "Tiny Tim" rockets carrying various types of explosive warheads for short ranges.

But one enters a wilderness of speculation as to the ultimate use of this proving ground of 1,000 square miles when, within its new laboratory facility, one is shown a new photographic technique, a research tool, capable of taking pictures in an exposure time of 1/100,000,000 second.

Desert flatlands and barren mountain areas of Arizona and New Mexico offer ideal locations, from the standpoint of their sheer isolation and the control of access roads against unwanted visitors, for the testing of still-secret rockets and their accessories.

At one time, within the past year, there was a strong possibility that at the U.S.-Mexico border town of El Centro, California, a long-range rocket testing station would be set up to fire its "birds" down the waterway of the Gulf of Lower California and thence out over the Pacific towards the Antarctic. The plan offered an ideal condition for calibrating initial flight from ground stations along the several hundred miles of the Mexican shoreline of the Gulf.

However, present indications are that the El Centro project has been abandoned, probably due to diplomatic coolness on the part of the Mexican government. Certainly the strong Soviet legation in Mexico City would question the "friendliness" of such a sanction to the United States !

For sheer isolation, and maximum secrecy in the testing of its "dream" vehicles of the outer space, the United States could hardly ask for a better spot than its atom bomb proving ground at the Marshall Islands in the mid-Pacific.

The recent testing of three atomic weapons at Eniwetok — from whence the radio-controlled B-17 drones departed in 1946 to fly through the saffron pillar left in the sky by the first Bikini A-bomb — established the degree to which apparently perfect secrecy could be maintained. The sea and sky for hundreds of miles in every direction

A "Tiny Tim" aircraft rocket hits the bull's eye.

can be cleared of observers — with the possible exception of submarines. The proximity of other islands is such that they offer ideal locations for radar observation posts for triangulation of high altitude flights during the periods of initial flight.

It all appears to add up to the United States' possession, today, of a combination of rocket flight facilities second to none.

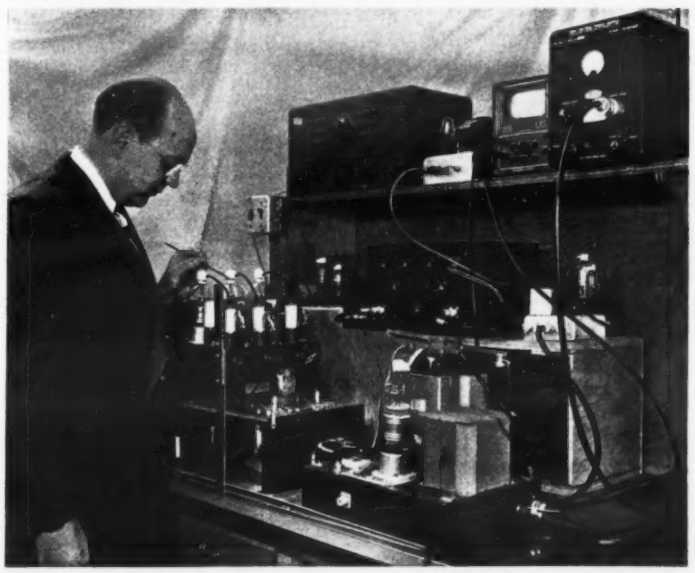
And if their intensive development is to be taken as indicative of progress being made within the heavily guarded walls of research laboratories, extremely interesting announcements may be made within a comparatively short time.

Dinner Guest, should he pick up his evening newspaper and read "MOON CLAIMED BY U.S.," will recall, then, the words of the mad youth who sat beside him, and will rush off importantly to tell the old boys of his club :

"I could have told you back in 1948 that this was coming. I got it straight from the man who did it !"

S.B.

The extremely high velocity of experimental guided missiles requires special photographic equipment capable of taking pictures in an exposure time of 1/100,000,000 second.



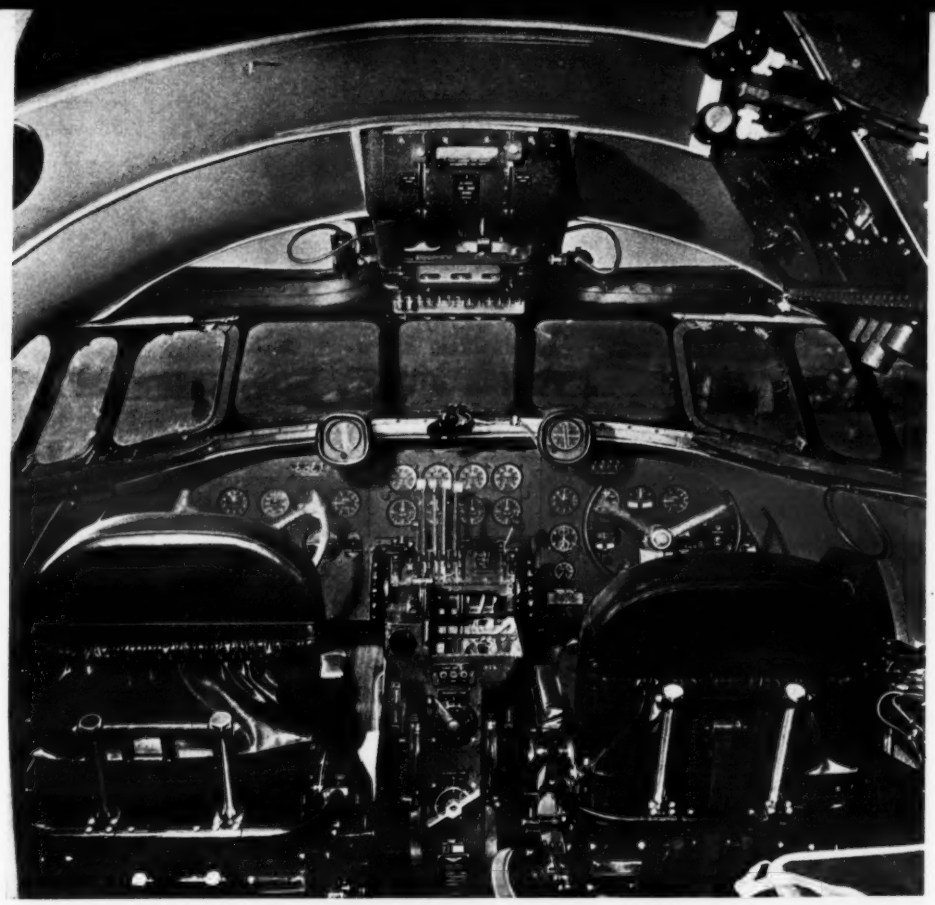
"No Entry"

A small metal plate on the door to the cockpit forbids passengers on commercial airliners to enter into a world which is invariably of burning interest to them. The domain of the pilot on board a large airliner is equally as much forbidden territory to the layman as the medicine chest of a doctor is to a patient. To the newcomer, the cockpit of a large aircraft, with its hundreds of instruments, pointers, dials, levers and switches, is just as overwhelming and mysterious in effect as the vaulted laboratory of an alchemist.

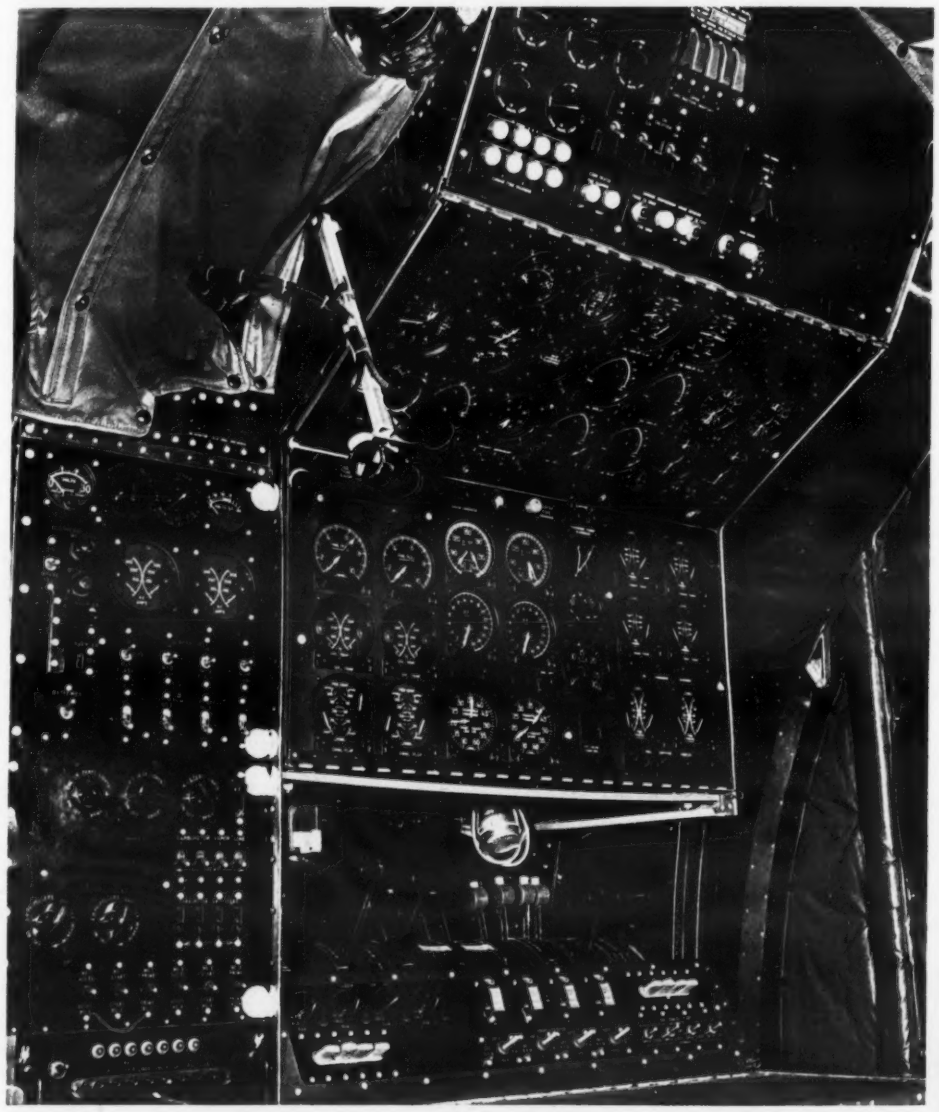
Passengers are not allowed to enter the pilot's compartment for a very simple reason : the cockpit is a place for intense work requiring a high degree of concentration ; every movement the pilot, co-pilot, radio operator or flight engineer makes, calls for precision and thought. There is neither time nor space for sight-seeing and explanations. And apart from this, it is well-known that the layman has the same weakness for levers and switches, especially when they are painted red and marked "Danger," as he has for a park bench bearing the inscription "Wet Paint."

What usually gives the impression of being a mad tangle and higgledy-piggledy arrangement of innumerable switches, lamps, dials and levers, is, as a matter of fact, a very carefully selected arrangement, well-thought-out and taking into account hundreds of small items. True, there are as yet no internationally valid standards as regards the layout of cockpits, and neither is the implementation of such specifications to be expected for many years to come. Individual groups of instruments, for example the blind-flying instruments, are nevertheless almost standardised as regards their composition and location in the pilot's compartment ; but the placing of the other equipment — indicators, engine servicing apparatus, cabin blower, navigational instruments, and so forth — differs in each aircraft.

Every aircraft manufacturing firm today has a considerable section of its engineering staff working on problems concerning the arrangement of the pilot compartment. With the introduction of multi-engined commercial transports, the consummation of relatively complicated navigational methods, and regular operations on long-distance routes, there arose



IN THE LOCKHEED "CONSTELLATION" COCKPIT, the only instruments in front of the pilots' seats are those for blind-flying and navigation ; between the two seats are r.p.m. and pressure gauges for the four engines. All other instruments are on the flight engineer's panel. Various controls and instruments are duplicated since, during flight, the flight engineer has to control engines, propellers, etc. He is additionally responsible for servicing various items of other equipment such as cabin-heating, pressurisation, fuel tank transfer, and so forth.



IN THE LOCKHEED "CONSTITUTION" FOUR-ENGINED AIRLINER, the same simplification is discernible, and this aircraft furthermore has a control pedestal between the pilots' seats. The flight engineer's station is more developed.

the necessity to alleviate the pilot in every possible way. The idea was therefore conceived to place before his seat only the instruments and engine controls necessary for the piloting proper, and to place all other instruments for watching over the engines, the electric and pneumatic systems, for servicing the fuel and oil circuits, cooling, cabin heating and pressurisation, illumination, and so forth, on a panel against the side-wall of the cockpit and to make them the responsibility of the flight engineer.

Even if all aircraft do not feature an absolute division between the pilot's and flight engineer's stations, it can be seen from the accompanying photos of two big aircraft, the Lockheed "Constellation" and "Constitution," how this feature has simplified the instrumentation in front of the two pilots. In case the reader should think that such simplification is merely to please pilots who wish to have their life as simple as possible, we would emphasise that it is indeed a necessity ; and this is evident from recommendations by the International Civil Aviation Organisation, which state : "The arrangement of the pilot compartment shall be such as to . . . ensure that [the pilot] will be able to perform all his duties and operate his controls in the correct manner, without difficulty, fatigue or concentration."

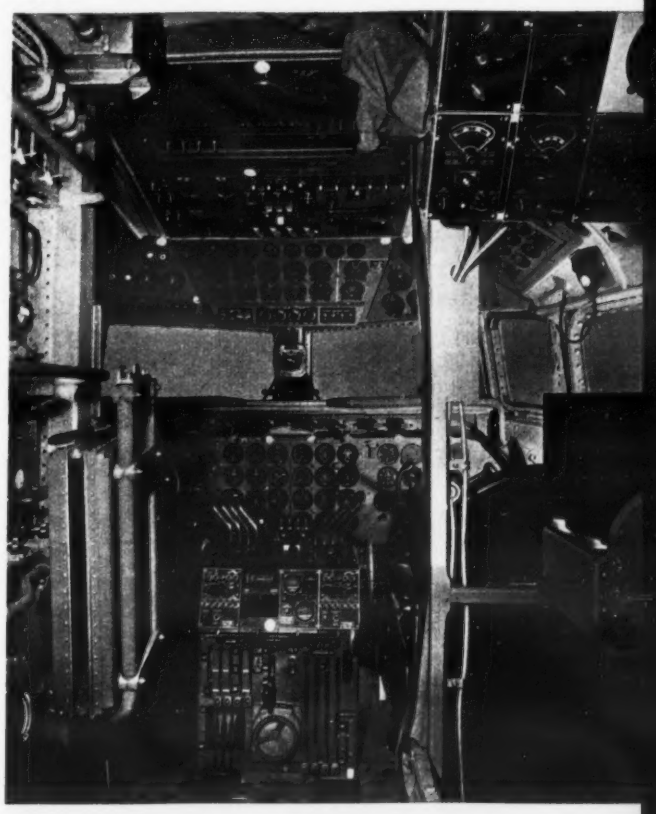
Aircraft engineers are sometimes apt to regard the desires of crew members as being exaggerated. It is difficult for them to put themselves in the crew's place ; they are unaware of the fatigue arising during long-distance flights, the strain imposed by inclement weather conditions, inexact or disturbed radio reception, noise, cold, and high altitudes.

Medical authorities maintain that piloting large airliners calls for men of more-than-average intelligence. At the same time they point out that such persons are more sensitive to the influences of noise, vibrations, temperature fluctuations, etc. Be this the case or not, it is a well-known fact that such irritating factors ultimately lead to chronic fatigue ; and people who fly only occasionally, are of course ignorant of these effects. It is therefore extremely important that the designers of the cockpit of a new airliner should take into account the experience and desires of the flight crew. It is the duty of the aircraft constructor to introduce even the smallest feature which can alleviate the pilot's task, since excessive fatigue must inevitably lead to errors.

It is astonishing how seemingly incidental things can cause a great deal of annoyance. Take for instance the arrangement of the hook on which the pilot hangs his microphone. During the course of a flight, he will reach for this microphone a great number of times, use it for a short while, and then hang it up again. If this hook is inconveniently placed, then the pilot may perhaps prefer to lay the microphone on his lap, from where it can easily fall, become damaged, and even damage other instruments. For this item, as for all the other objects frequently used in the cockpit, the following rule should be made : location so natural that the pilot can reach for it and put it back without looking in that direction.

When flying at great altitude, the crew may find it necessary to use oxygen masks. Oxygen hose, and incidentally the cord to the earphones too, have a habit of catching on everything that juts out, thus hindering the wearer's movements. Sharp corners in the cockpit have therefore to be avoided as

IN THE DOUGLAS DC-6, the flight engineer's station is not so sharply divided off. All instruments are therefore located above and between the pilots' seats, whereas the flight engineer sits on a flap-seat behind the central instrument pedestal. A great number of the instruments are on the ceiling, so that they can be controlled and serviced by the pilots and the engineer.



TO FACILITATE CO-OPERATION BETWEEN CREW MEMBERS ON THE NEW BOEING " STRATOCRUISER," the flight engineer's instruments are grouped on a panel placed against the side-wall of the cockpit, directly behind the pilots' seats.

IN THE WORLD'S BIGGEST LANDPLANE, THE CONVAIR XC-99, the division between navigational and blind-flying instruments and the other equipment has been carried out consistently. Space has enabled the pedestal between the pilots' seats to be widened so that it can simultaneously serve as a table for the flight engineer, who sits in the centre of the cockpit.

much as possible, and switches and levers arranged so that they cannot be actuated "by mistake."

Of course, these demands are not entirely new, because ever since aircraft have existed, crews have complained about sharp edges, difficultly accessible handwheels, and concealed switches continually resulting in skin abrasions and minor injuries.

Attempts have been going on for some time to prevent crew members from executing faulty manœuvres, by giving the most important levers a special form and by using different colours, and so on. Although all this does seem to have helped indirectly, it would seem more important to standardise, for all aircraft, the positions of certain controls, for instance those for the flaps and undercarriage. Innumerable aircraft of all categories, from trainers to multi-engined airliners, have met with disaster because the pilot confused these two controls. Crew members who have to fly different aircraft types, cautious as they may be, are constantly endangered by the force of habit. (Even a motorist finds himself faced with difficulties if he has to change over to a car in which the brake and clutch pedals have been interverted.)

Just as important as standardising the position of certain levers is also to standardise their direction of motion. The rule that all switches and controls for "take-off" or "on" should be moved forward, is not new and is, as a rule, applied. But unfortunately — only as a rule ; exceptions are to be found again and again, which sooner or later are bound to lead to accidents.

The bigger the aircraft, the more important become all questions of work distribution between the crew members, and the housing of the constantly-increasing number of instruments. For reasons of space, it has become a practice in the last ten years to place certain groups of instruments on the ceiling of the cockpit. Various aircraft manufacturing firms, such as Douglas Aircraft Co. with the DC-6, Boeing Airplane Co. with the "Stratocruiser," or Consolidated Vultee with the XC-99, have endeavoured to facilitate co-operation between the pilot and flight engineer by placing the latter's station directly aft of the pilot's seat, in the centre of the cockpit. In this case, a great number of instruments are located on the pedestal between pilot and co-pilot, the dual arrangement of instruments or controls is avoided in many instances, and a direct means of mutual control is offered. In big aircraft which provide sufficient space for this arrangment, it is likely that it will be adopted.

The Prospects of Jet Reaction Flight

By Dr. Eugene SAENGER, Paris. *(Continuation *)*

4. *Flame Tube.* The flame tube of a rocket gives rise to a whole series of special problems. Since its purpose is to achieve the supercritical expansion of the combustion gases, it consists, like a Laval duct, of a convergent part extending to the narrowest cross-section f', and of a divergent section continuing up to the outlet cross-section f_m.

According to the already-mentioned formula, the effective efflux velocity in the narrowest cross-section, with $\kappa = 1.25$, already amounts to about 60 per cent. of the value theoretically obtainable through expansion, so that the thrust contribution of the divergent part of the duct does not exceed in practice about 20 per cent. of the theoretical maximum thrust, whereas the remainder, because of the constructionally impossible size of the cross-sectional areas, is lost anyhow. Nevertheless, in view of the great importance of gaining every bit of effective efflux velocity, great attention is also attached to the divergent part of the duct.

The characteristics of the supersonic flow in the divergent part, particularly the sharp decreases in pressure in the direction of flow (which preclude any breaking away of the boundary layer), enable very considerable angles of aperture to be utilised, which can be a multiple of those of a Laval duct. As a result, in spite of the large absolute cross-sections, the duct is short and the critical walls touched by the flames shrink considerably.

In the case of conical-shaped divergent parts featuring total angles of aperture of over 25 deg., the obliquity of the exterior velocities of the gas jet relative to the axis of the duct entails a noticeable decrease in thrust. In such cases a curved generating line is used to redirect the gas jet parallel to the rocket axis at the outlet, so that even in the case of very large angles of aperture, there is no dispersion of the impulses at all, and one obtains the same thrust as with a long Laval duct. For the particular case of rotationally-symmetrical ducts, even for variable values of κ, three-dimensional curves of supersonic flow were plotted in order to calculate these generating lines. Working out their form for more general conditions, however, calls for further research.

This applies especially to the behaviour of the combustion gases during the actual expansion. In order that the chemical equilibria in the combustion gases may establish themselves practically completely after a major change of state, it has been seen from experience that it is necessary for every molecule to be subjected to about 10^7 collisions. The mean number of collisions which a molecule receives per second being $Z = 10^7\, p/\sqrt{T}$ (in dependance of the gas pressure p and the absolute gas temperature T)—for example $Z = 1.6 \times 10^{11}$ for $p = 10^6$ kg/m^2 and $T = 4{,}000$ deg. K.—reveals that the requisite reaction periods of about 10^{-4} seconds can easily be coped with during the gases' storage life of 10^{-2} seconds in the combustion chamber, and that the chemical equilibria will be well established.

Flowing the distance l along a duct, the number of collisions of a molecule is about $Z' = (10^7 p/\sqrt{T})\ (l/\bar{w})$, wherein $\bar{w}$ indicates the mean velocity of flow per unit of time. In the narrow section of the flame tube, this number will exceed 10^7 if $l = \dfrac{\bar{w}\sqrt{T}}{p} > 0.06$ m in a 100-atmosphere rocket and superior to 0.6 m in a 10-atmosphere rocket. The establishment of equilibrium in the narrow section will hence be achieved with a larger degree of probability in large high-pressure rockets than in small low-pressure rockets.

In the divergent section of the duct, with its lower pressures and higher velocities of flow, the distances of flow l necessary so that the equilibrium may be established are so considerable that even in very large high-pressure rockets the establishment of the chemical equilibrium may not be counted on with absolute assurance.

The problem of establishing the equilibrium of the combustion gases in the flame tube is nevertheless of great practical importance, since it can give rise to differences in efflux velocity of over 10 per cent. Apart from this, the configuration of the duct itself is dependent on it—for instance, smaller values can apply in the narrow section than the divergent one—and its advantages are presumably favoured by large high-pressure rockets, so that development will in all likelihood proceed in this direction.

Meanwhile, however, there is a whole series of other reasons for this developmental tendency, such as the lower thermal dissociation from the start when the combustion pressures are high, the larger drop in pressure utilisable in the expansion and the concomitant improved transformation of enthalpy into kinetic energy, the smaller rocket dimensions and smaller areas touched by the flames, and the resultant decrease in total heat transmitted.

5. *Fire Walls.* An arbitrary increase of the combustion pressures and temperatures is primarily limited by the impossibility of constructing sufficiently resistant fire walls.

In practice, these walls are always crystal lattices with the least possible permeability for the particles of combustion gas involved, in order to be able to direct the latter in the direction of the axis of the rocket.

It follows from the constant lattices available in practice, of about 10^{-8} cms., that a more or less complete impermeability can be attained only for particles of similar magnitude, thus molecules and atoms, whereas nuclear particles, electrons, photons, and so forth, are generally absorbed to a large extent, or even penetrate partially through the walls. With rising combustion temperatures, especially in the domain of atomic fuels, the proportion of these particles in the combustion gas increases strongly, to such an extent that the usually resistant combustion chamber walls become in principle less and less efficacious and more and more permeable.

The question of whether the field forces of the crystal lattice, which are insufficient under these conditions, might be replaced by electric fields sufficiently effective for reflecting at least all electrically-charged flame particles, is still completely unsolved.

For some time to come, the construction of fire walls for rockets will be restricted to reflecting the major energy carriers (atoms and molecules), under the supposition that the walls absorb energy, feeble for the time being, in the form of photons and electrons.

This radiation contribution of the heat transmission from the combustion gas to the walls still requires a great deal of clarification, especially as regards the components resulting from the perturbed state of the combustion gases, such as chemiluminescence, etc. Nevertheless, it seems certain that, within the range of combustion temperatures interesting us for the time being, thus up to equilibrium temperatures of about 5,000 deg. K., the total radiation of the combustion gases will not exceed 10 to 20 per cent. of the radiation of an equally hot black body.

Meanwhile, the reflection of larger particles, such as atoms and molecules, from the wall is by no means elastic, *i.e.* without loss

* Cf. "Interavia, Review of World Aviation," No 9, Vol III, pp. 499-506.

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of energy ; on the contrary, these particles penetrate into the wall, where they assume the temperature of the crystal lattice, and after a finite period of time, emerge at a velocity corresponding to the temperature of equilibrium, in an arbitrary direction, with a result that the reflection is at once diffuse and plastic.

If the molecular mean free paths were comparable with the dimensions of the combustion chamber, the enthalpy furnished to the gases would communicate principally with the walls and not lead to high efflux velocities. It is only thanks to the small mean free paths that each gas particle does not come into contact with the wall, but only a certain number of the particles from the thin boundary layers of the flow, so that only the zones of the boundary layer close to the wall are cooled to the wall temperature, whereas the layers of gas situated further away from the wall lose but very little of their enthalpy by convection. The mechanism of this gas convection for short mean free paths and small velocities of flow is sufficiently known for one to be able, in numerous instances, to calculate the transmission of heat in kcal/m²h with formulæ of the Merkel type :

$$Q/F = 0.075\ (w \cdot \rho \cdot g \cdot c_p)^{0.75} (\lambda/l)^{0.25} \cdot \Delta T$$

wherein the symbols represent, in the above order, the quantity of heat (kcal), the area (m²), the velocity of flow (m/h), the density of the gases (kg h²/m⁴), the acceleration of gravity (m/h²), mean specific heat of the gases (kcal/kg°K.), the mean thermal conductivity of the gases (kcal/mh°K.), the length of flow (m), and the variation of temperature in the boundary layer (deg. K.).

It is evident that the density of flow ρw exercises a major influence over the transmission of heat, which clearly explains the fact that the transmission of heat is very critical in the narrowest cross-section of the rocket, and can attain values varying between 1 and 10 H.P./cm.².

Nevertheless, the hypotheses used in this calculation apply only in great approximation to the combustion gases of a rocket, *e.g.* because the low temperature of the boundary layer zones located near to the walls gives rise to a strong recombination of the combustion gases, entailing a considerable transmission of heat direct to the wall, and because at sonic and supersonic velocities of gas flow, the strong ram temperature effects in the boundary layer increase the drop in temperature. Hence the study of convection in these conditions is also a predominant research problem of rocket-propulsion technique.

According to proposals put forward by Mr. H. Oberth, successful trials were made to diminish the convection at the fire walls by means of thin films of cool vapours or gases flowing between the wall and the combustion gases, which remained there for a long time, especially when the supersonic flow was very stable.

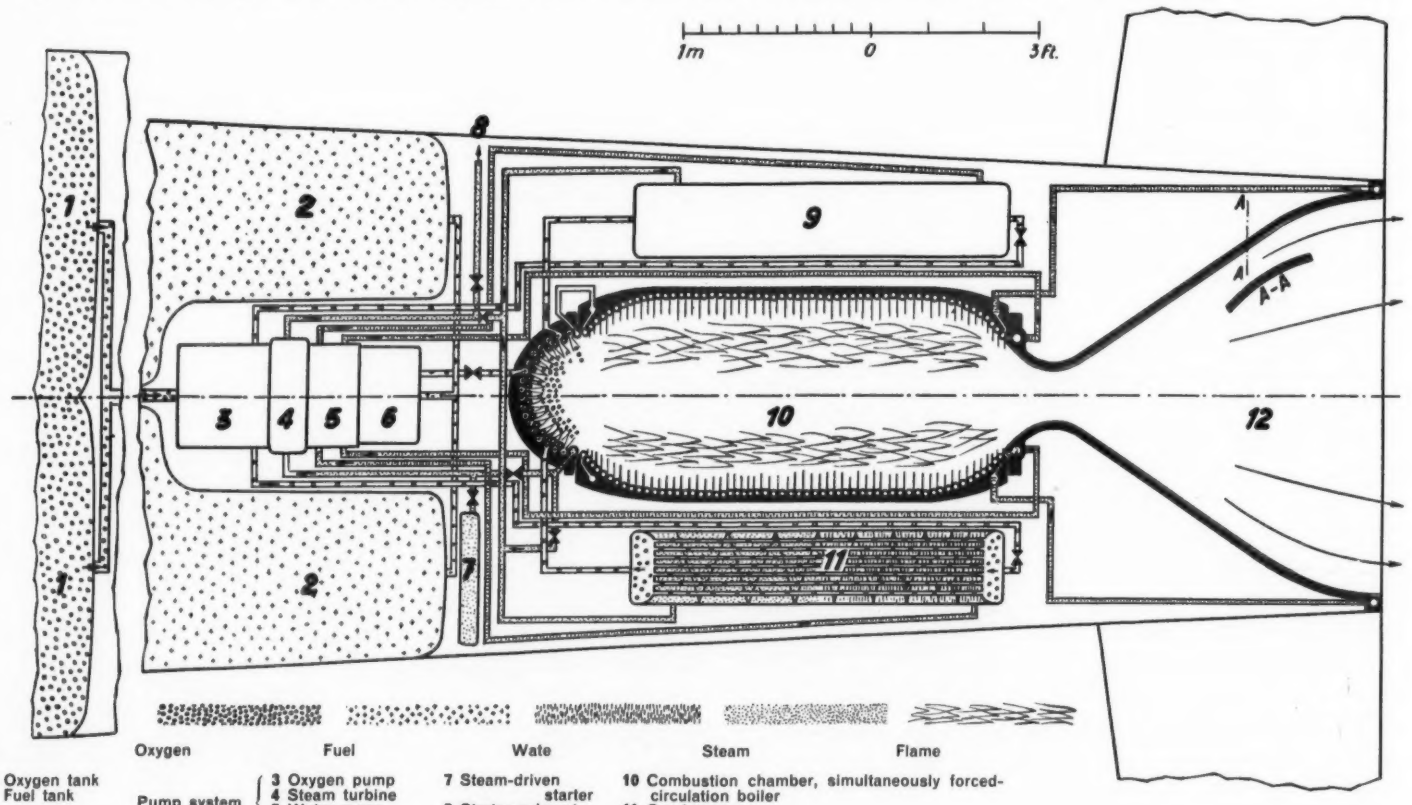
Since the combustion gases always contain a large number of ions, one could imagine a way of compelling the entire mass, or at least the boundary-layer gases near to the wall, to move in a given manner by electrically influencing these ions, and thereby also reducing the transmission of heat by convection.

The reverse problem arises on the other side of the walls touched by the flames (these walls are mostly only a few millimetres thick) where the transmission of heat in the coolant boundary layer, with a limited drop in temperature, must be equal to the transmission of heat on the flame side. Hence there must be a tendency towards coefficients of transmission of heat which are as high as possible. These coefficients depend (in a manner which is still very vague) on the characteristics of the coolant (thermal conductivity, specific heat, density, temperature, pressure, velocity of flow, viscosity) and on the characteristics of the coolant's channels (area, cross-sectional dimensions).

Since a major use will be made of liquid coolants (fuels, water, liquid metals), it must be remembered that the peak temperature in the zones near to the wall of the coolant boundary layer will frequently attain the boiling point of the coolant at the pressure existing in rockets, the coolant thus being subjected to local vaporisation in these boundary-layer zones. The turbulence transports this vapour in the cooler boundary-layer zones where, in the free flow of the coolant, it immediately recondenses, so that transportation of very intense heat can be achieved through the medium of the vaporisation heat, and the cool-edge wall can be kept practically at the temperature of vaporisation of the coolant. Nevertheless, if the vaporisation zones spread over large areas of the boundary layer, or even as far as the free flow of the coolant (*i.e.* if the entire mass of the coolant begins to vaporise), the condensation and the transportation of heat stops suddenly, the coefficient of transmission of heat drops at once, and the cool-edge temperature rapidly attains menacing values.

Not until considerable parts of the coolant mass have vaporised will the general velocity of flow, in view of the low densities, increase

Fig. 14 : General arrangement of the main components of a rocket power plant, drawn inside the rear fuselage of a rocket aircraft.



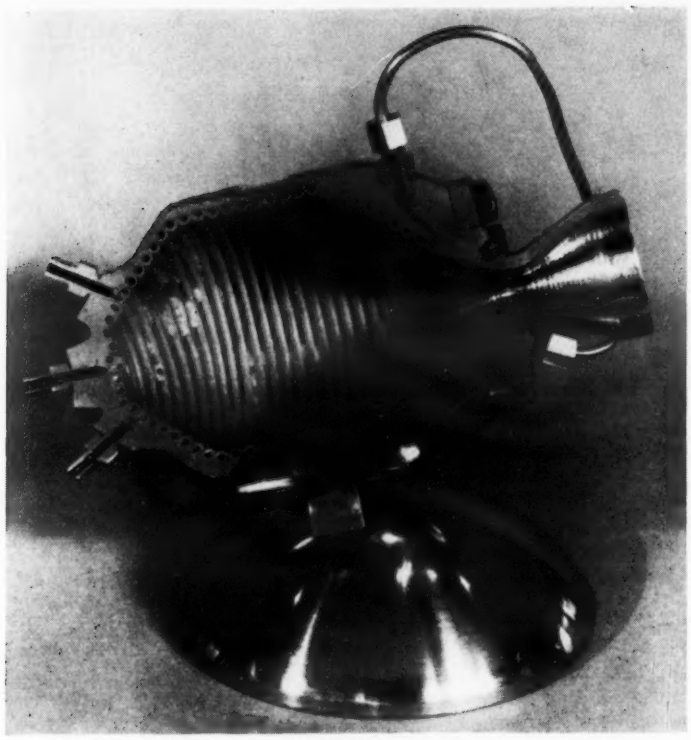


Fig. 15 : Sectional view of a scale-model of a high-pressure chemical rocket (mixture of gas oil, liquid oxygen and liquid ozone), with forced-circulation cooling and large-aperture nozzle.

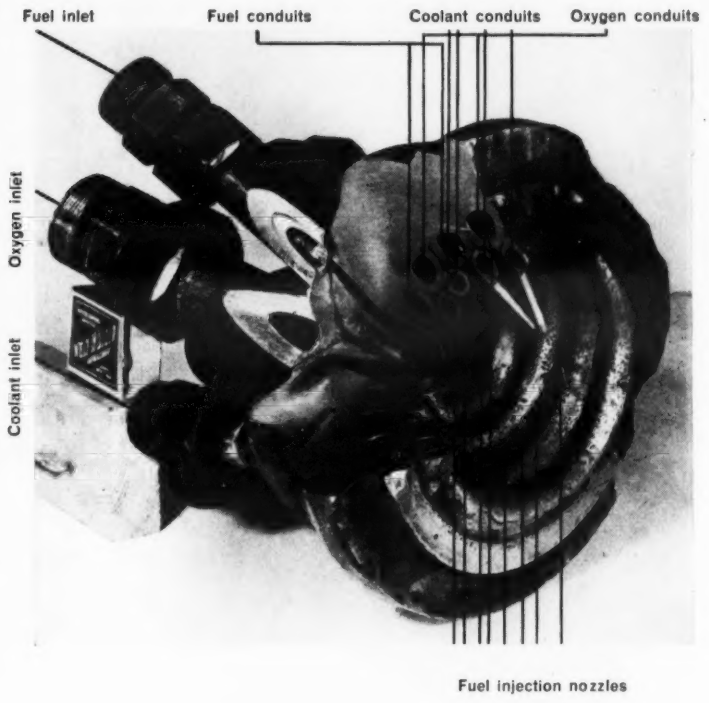


Fig. 16 : Head of a high-pressure chemical rocket, giving intense macro-mixture, through very many injection nozzles, of liquid oxygen and liquid ozone.

sharply enough for the heat transfer coefficients to resume utilisable values.

By augmenting the pressure in the coolant, these dangerous phenomena of the initial boiling can be kept down, and made almost to disappear at pressures exceeding the critical pressure. For example, it is known that the vapour from over-heated water at a pressure superior to 100 atmospheres yields, already at velocities of a few metres per second, transmissions of heat which are just as favourable as those of water.

Hence, whereas we have been able to determine that there is a tendency towards high pressures for the combustion chambers of rockets, this characteristic applies all the more to the cooling channels.

High heat convection is physically coupled with high frictional drag in the boundary-layer of the coolant, and to overcome this it is inevitable that there be strong losses of pressure in the cooling circuit. The demand for high coolant pressures puts a provisional limit on the velocity in flat cooling sleeves, this being for reasons of mechanical resistance. Working under such conditions, cooling systems of numerous different designs, using limited combustion temperatures, have revealed adequate convection and thus proved their practical usefulness.

With a tendency towards higher efflux velocities, *i.e.* in the majority of cases towards higher combustion temperatures, it is necessary to have, at least locally, an increase in the velocity of the coolant in the region about the neck of the duct, and this is accomplished by narrowing the coolant's flow cross-sections and by using systems with forced circulation.

By connecting the two walls of the channels by means of partitions, one can fortunately form cooling channels of which the mechanical resistance is similar to that of tubular sections and sufficiently high to withstand the increasing pressures in the coolant.

These rocket fire walls divided into several channels for resisting the pressure of the coolant and its forced circulation, are today regarded as representing a more or less definite solution which can satisfy rigid demands as regards combustion temperature and pressure.

Since the decrease in specific consumption, which can be expressed as an increase in the rocket's effective efflux velocity, is limited by sufficient cooling of the walls, it seems that, under extreme conditions such as atomic combustion, it is not excluded that one could arrive at a solution involving a combination of the forced circulation of the high-pressure coolant, cooling by means of "films", and perhaps cooling through the medium of an electric field.

The very important problem of cooling rockets is further complicated by the fact that, physically speaking, the plastic collisions of the combustion gas particles, from molecules to photons, against the atoms of the crystal lattice of the wall, endow these atoms with vibrations of such magnitude that the lattice tends to collapse before its atoms can radiate sufficient energy. Expressed technically, this means that the softening points of all known construction materials, which attain a peak temperature of nearly 5,000 deg. C. in graphite, is too far below the combustion temperature to allow for the establishment of an exchange of heat in stationary state.

Thus it is often no longer the softening point or the beginning of chemical changes which are alone determinant for the choice of constructional materials for cooled walls, but the exchange of heat possible for a given strength of the wall ; thus, for instance, the product of the thermal conductivity λ, the difference between the admissible fire-edge temperature t_f and the cool-edge temperature t_k used, and the pertinent high-temperature stability σ of the constructional material. The material quality index $\lambda\ (t_f - t_k)\ \sigma$ thus obtained reveals that materials such as aluminium, copper, iron, nickel, austenitic nickel-chromium steels, platinum, iridium, tungsten, etc., are the most favourable, according to the temperature chosen for the cold wall.

Fig. 17 : Experimental vaporisation system of the combustion chamber of a 100-tonne high-pressure rocket.

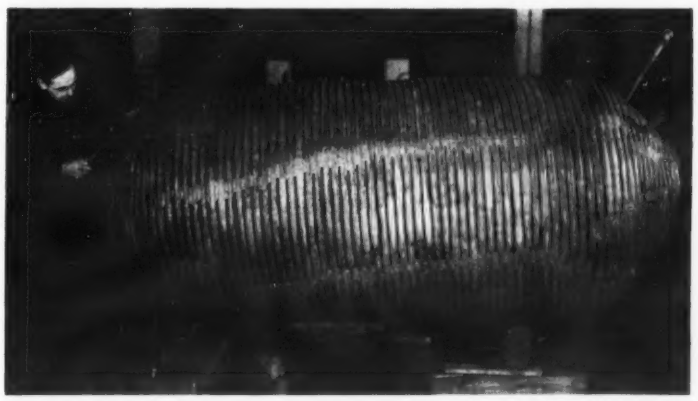


Fig. 18: Liquid-oxygen tank, built to contain 56 tonnes, being tested.

Since, on the other hand, the difference between t_k and the coolant temperature has been seen to determine the transmission of heat from the cooling side, this difference must therefore be as high as possible and development will proceed in the direction of materials having high quality indices at high t_k values, such as austenitic steels, platinous metals, sinter metals, etc.

Finally, it can prove useful to use even multi-layered fire walls, in which the constructional materials of the different layers are scaled according to the temperature to which they are subjected, and the mechanical functions are handed over to the most suitable materials in the cooler zones of the wall (*e.g.* enamelled steel, chromium plating, protective layers of sinter ceramic, plated metals, etc.).

6. *Fuel Supply.* One of the most important secondary problems connected with pure rocket propulsion concerns the delivery of fuel from the tanks against the constant high combustion pressure in the chamber. A standard pumping system, with fuel pump, oxygen pump, driving turbine and eventually coolant pump on a common shaft, seems to have been adopted, whereby high-speed centrifugal pumps are always used for distributing large quantities of fuel.

Meanwhile, however, there still exists a divergency of opinion on the source of energy for the driving turbine. The frequently used process of producing over-heated steam in a special generator — *e.g.* by dissociation of hydrogen peroxide—may only be regarded as a particularly simple initial solution, because the supplementary consumption (of about 2 per cent. in V-2 rockets) is already noticeable and increases rapidly with the combustion pressure.

The extraction of a suitable fraction of combustion gas from the rocket's combustion chamber—extracted gases are led into the auxiliary turbine after suitable cooling—indeed yields a lower consumption, but also gives rise to secondary problems as regards cooling and brings to light the familiar gas-turbine worries in connection with the auxiliary turbine.

A system which is more complicated from the constructional standpoint but entails no supplementary consumption, consists in vaporising the coolant with the aid of the transmission of heat through the walls of the rocket, and utilising this vapour for driving the auxiliary turbine ; in condensing the coolant in condensers cooled by liquid oxygen, and in subsequently returning it to the cooling circuit of the rocket. It may safely be assumed that this process will find application, especially in large high-pressure rockets placing rigid demands on effective efflux velocity.

In this case, rockets with forced cooling work like high-pressure radiation steam boilers with forced circulation, of the same type as the Benson, La Mont, Velox, Sulzer, etc., boilers, which they also resemble constructionally in many ways.

7. *General Arrangement.* Fig. 14 shows diagrammatically the general arrangement of chemically-propelled rockets of this type, and Figs. 20, 21 and 22 photographs of a four-minute test of a scale-model combustion chamber of this design working at a combustion pressure of 73 kg/m² and furnishing about 1 tonne of effective thrust. being fuelled with gas oil and liquid oxygen.

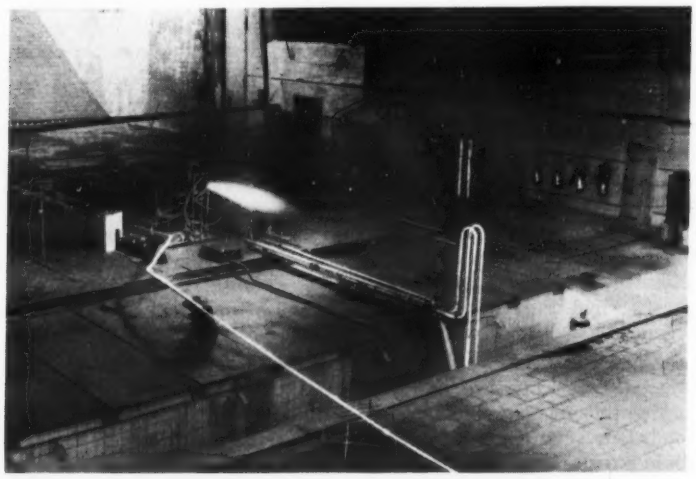
D. Rocket Aircraft

Alongside the power plant characteristics, the main basis to the construction of rocket aircraft is high-speed aerodynamics. Apart from the flow phenomena at speeds close to that of sound, which are already to the forefront, the aerodynamics of rocket aircraft are concerned with three major domains: that concerned with moderate supersonic speeds up to about Mach 5, that of high Mach numbers approximately between 5 and 30, and the domain of very great flight altitudes where the molecular mean free paths are large. As regards their characteristics and constructional consequences, these three domains are very different from one another.

1. *Moderate Mach Numbers.* Characteristic for this range of supersonic velocities from $v/a = 1$ to 5 is the behaviour of thin, sharp-edged aerofoil sections of infinite span as clarified by Ackeret.

Fig. 19: High-pressure oxygen pump, for delivering at 150 kg/m², about to be tested (delivers 5 kg/sec.).

Fig. 20: One-tonne-thrust bench trial of a gas-oil—liquid-oxygen rocket at 30 atmospheres combustion pressure.



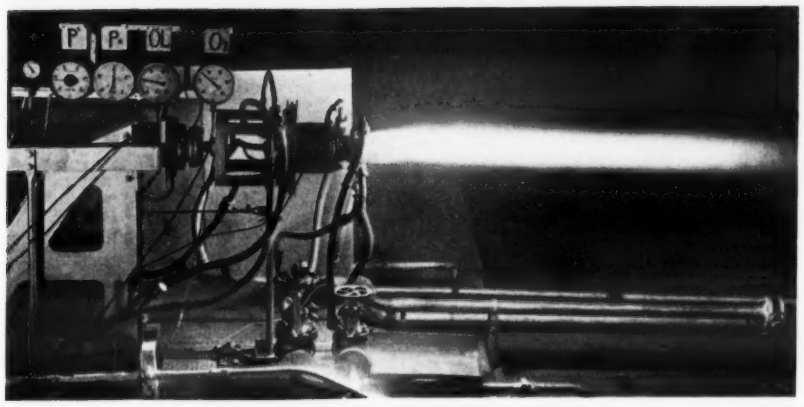


Fig. 21 : Same test equipment as in Fig. 20, but at 40 atmospheres combustion pressure.

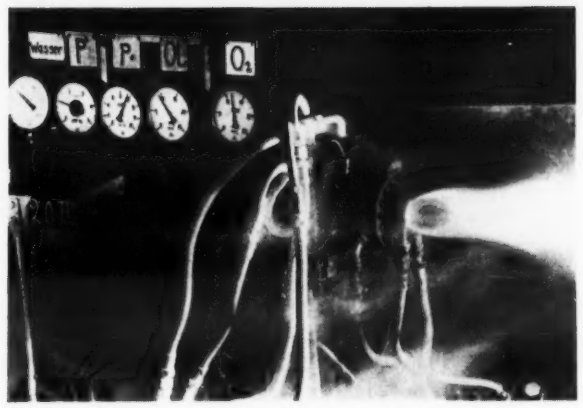


Fig. 22 : One-tonne-thrust bench trial of a gas-oil—liquid-oxygen rocket at 100 atmospheres combustion pressure.

Referred to the dynamic pressure $q = \rho v^2/2$, the local positive and negative pressures Δp are proportional to the local angle of incidence α_x, in accordance with the relation :

$$\frac{\Delta p}{q} = C_1 \alpha_x = \pm \frac{2\alpha_x}{\sqrt{\frac{v^2}{a^2} - 1}}$$

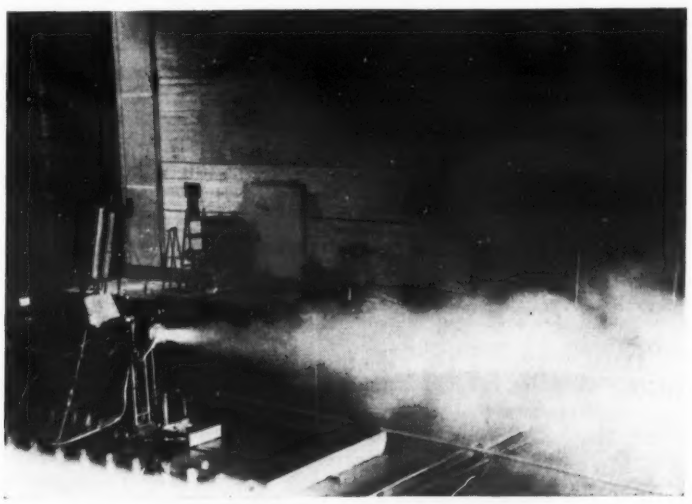
If one applies this simple pressure law to a biconvex symmetrical aerofoil section such as that shown in Fig. 12, for example, which has the thickness d and the chord t, one finds the distribution of the linear pressure diminishing with the chord of the aerofoil section, both on the suction side and the pressure side; this indicates that the centre of pressure always coincides with the centre of gravity of the aerofoil section, and that this consequently fulfils the demands made of an ideal laminar aerofoil section. By integrating the pressures, it is easy to find the classical coefficients of the aerofoil section:

$$c_a = \frac{4a}{\sqrt{\frac{v^2}{a^2} - 1}} \; ; \; c_w = \frac{\sqrt{\frac{v^2}{a^2} - 1}}{4} c^2{}_a + \frac{16}{3\sqrt{\frac{v^2}{a^2} - 1}} \left(\frac{d/t}{1 + d^2/t^2} \right) + 2 \frac{1.327}{\sqrt{Re}}$$

wherein the first term represents the drag of a flat plate, the second the drag arising from the finite aerofoil thickness, and the third the laminar frictional drag.

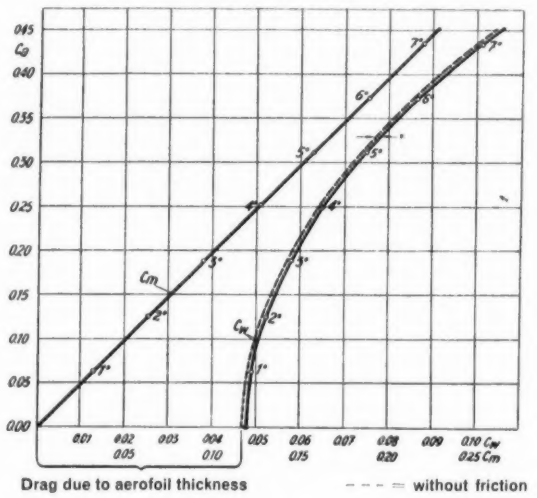
$$c_m = 0.5 \; c_a$$

Fig. 23 : Bench test of a 1-tonne-thrust rocket, propelled by gas oil with suspended aluminium, and liquid oxygen (the aluminium oxide forms a white fog in the efflux jet).



In the case shown here, $v/a = 1.5$, $Re = 10^7$, $\frac{d}{t} = 0.1$; one therefore finds an optimum lift/drag ratio $(c_a/c_w)_{max} = 4.35$ at $c_a = 0.415$.

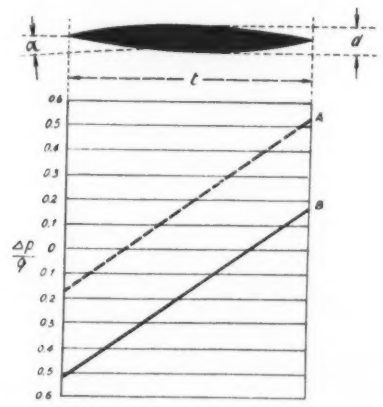
Fig. 24 : Theoretic polar curve of a symmetrical lens-type aerofoil section— $d/t = 0.1$ for $v/a = 1.5$ and $Re = 10^7$ (two-dimensional flow).

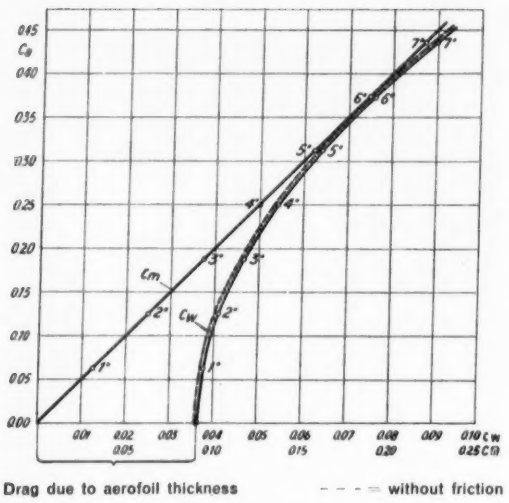


Equation of force polars :

$$c_w = \underbrace{\frac{16}{3\sqrt{v^2/a^2 - 1}} \left(\frac{d/t}{1 + d^2/t^2} \right)^2}_{\text{Pressure drag due to finite aerofoil thickness}} + \underbrace{2 \frac{1.327}{\sqrt{Re}}}_{\text{Laminar frictional drag}} + \underbrace{\frac{\sqrt{v^2/a^2 - 1}}{4} c_a{}^2}_{\text{Pressure drag of flat plate}}$$

Equation of moment polars : $c_m = 0.5 \; c_a$
Centre of pressure at the aerofoil centre

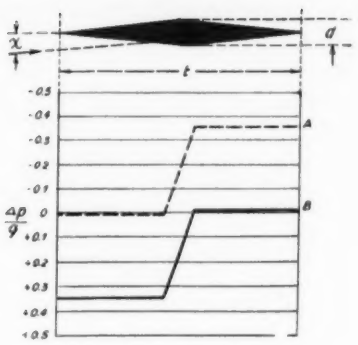




Equation of force polars :

$$c_w = \underbrace{\frac{4}{\sqrt{v^2/a^2-1}}\left(\frac{d}{l}\right)^2}_{\text{Pressure drag due to finite aerofoil thickness}} + \underbrace{2\frac{1.327}{\sqrt{Re}}}_{\text{Laminar frictional drag}} + \underbrace{\frac{\sqrt{v^2/a^2-1}}{4}\,c_a^2}_{\text{Pressure drag of flat plate}}$$

Equation of moment polars : $c_m = 0.5\ c_a$
Centre of pressure at the aerofoil centre



Pressure distribution for $a = 0.0998$
A = Suction side
B = Pressure side

Fig. 25 : Theoretical polar curve of a rhombic aerofoil section—$d/t = 0.1$ for v/a and $Re = 10^7$ (two-dimensional flow).

By applying Ackeret's theory to a rhombic aerofoil section of the type shown in Fig. 25, one arrives at the corresponding formulæ :

$$c_a = \frac{4a}{\sqrt{\frac{v^2}{a^2}-1}}\,;\ c_w = \frac{\sqrt{\frac{v^2}{a^2}-1}}{4}\,c_a^2 + \frac{4}{\sqrt{\frac{v^2}{a^2}-1}}\left(\frac{d}{l}\right)^2 + 2\frac{1.327}{\sqrt{Re}}$$

$$c_m = 0.5\ c_a$$

For the same example as above, one finds an optimum lift/drag ratio of about $(c_a/c_w)_{max} = 4.91$ for $c_a = 0.36$, thus a noticeably superior lift/drag ratio in so far as one can still count on the same degree of laminar friction as in the preceding example, notwithstanding the less favourable distribution of pressure.

These characteristics have made the rhombic aerofoil section very interesting for supersonic wings, and this all the more because, in the subsonic domain, one may anticipate values of c_a which are sufficient, and relatively independent of the Mach number, owing to the fact that the flow along the suction side breaks away entirely.

The sharp leading edge of supersonic aerofoil sections, contrary to the rounded edge of subsonic sections, suppresses the drag-producing shock wave perpendicular to the wing flow in front of the vertical tangential plane of conventional aerofoil sections, in such a way that this plane is, so to speak, turned through 90 degrees about the horizontal axis of the wing. Attempts have also been made to turn this plane about a vertical axis, in order to postpone the vertical shock wave with sharp sweepback of the rounded leading edge, but the angles of sweepback are of course limited in this direction. Mach 2, for instance, demands angles of sweepback of over 60 degrees, which goes to say that, however valuable this procedure may be in the sonic domain, one rapidly comes up against a brick wall when the flying speeds continue to increase. Nevertheless, it is quite justified for sonic aircraft powered with ram-jets, since it gives unperturbed flight at sonic speed.

Another important problem in connection with supersonic flow is that incurred by the increase in temperature ΔT owing to the friction in the boundary layer, and by the resultant transmission of heat through the outer walls of the aircraft. At present one calculates for ΔT, for laminar or turbulent boundary layers, about 85 per cent. of the increase in temperature due to the adiabatic compression of the air outside the boundary layer, thus

$$\Delta T = 0.85\ \frac{v^2}{2\,g\,c_p} = \frac{v^2}{2{,}360}$$

if the wall touched by the boundary layer is itself subjected to this increase in temperature. In the case of the flat plate positioned parallel to the direction of flow, v is therefore the flying speed and ΔT has to be added to the temperature T of the undisturbed ambient air. In the case of curved bodies, around which, with the exception of the boundary layer, the flow is entirely adiabatic, the local temperatures and velocities outside the boundary layer may be zonally superior or inferior to the corresponding values in the undisturbed ambient air, so that the values of ΔT are superior or inferior to those they would assume in the case of the flat plate ; consequently, the maximum temperature of the boundary layer, because of the varying contribution of the non-adiabatic heating of the boundary layer, may be higher than in the case of the flat plate (up to full ram temperature $T_{st} = T + v^2/2\,g\,c_p$ or, in the overspeed zones, lower than in the case of the flat plate.

In cases of non-adiabatic flow, shock waves, breakaway of the boundary layer, cooler wall, etc., the boundary-layer temperature will be lower.

At all events, all the surfaces of the aircraft touched by the relative wind are covered with a very snugly fitting layer of hot air, the temperature of which, *e.g.* at Mach 5, is about 1,000 deg. K. above that of the undisturbed ambient air. This layer heats the aircraft considerably by transferring heat to the walls ; very little research has been effected so far on this transmission of heat.

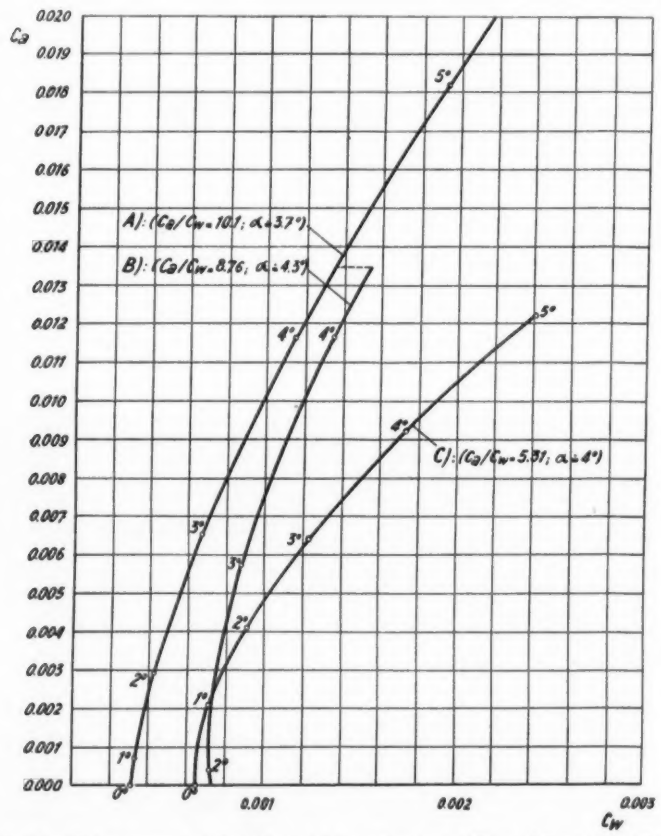


Fig. 26 : Polar curves of flat plate (A), wedge-type (B) and lens-type (C) aerofoil sections, in a flow governed by gas dynamics, at a Mach number $v/a = \infty$.

2. *High Mach Numbers.* Within the range of the high Mach numbers, the approximate formula devised by Ackeret, $\Delta p/q = \pm C_1 \alpha_x$ is no longer sufficient. Account must therefore be taken of the higher terms of the series

$$\Delta p/q = \pm C_1 \alpha_x + C_2 \alpha_x^2 + (C_3 - D) \alpha_x^3 + \ldots .$$

until, for $v/a \rightarrow \infty$, there remain only the relations of the oblique shock wave to the very high Mach numbers :

$$\Delta\rho = \frac{2}{\kappa + 1} \rho v^2 \sin^2 \alpha_{sl}; \Delta\rho = \frac{2}{\kappa - 1} \rho; \Delta T = \frac{2\kappa}{(\kappa + 1)^2} \frac{A v^2 \sin^2 \alpha_{sl}}{g c_p}$$

With the increasing velocities of shock, the interior degrees of liberty of the molecules will participate to an increasing extent in the absorption of energy, notably through energisation of the oscillation quanta of the N_2, O_2 and H_2O. Finally, in view of the dissociation of these molecules, the specific heat c_p will increase sharply, and κ will deviate from its usual value of 1.4 in order to tend towards unity. The resultant increasing isothermic flow, $\Delta T = 0$, creates directly on contact with the walls a shock with infinitely large air density, $\Delta\rho \rightarrow \infty$; one can calculate the contribution of pressure arising from the shock impulses of the molecule according to the old formula of Newton, $p/q = 2 \sin^2\alpha$, especially since the initial molecular agitation of the air owing to the heat is negligible in comparison with the great flying speed v.

After the shock against the body, the air shifts along the surface of the body as an infinitely thin layer, at a constant speed, along geodetic lines, so that one can calculate the centrifugal forces acting on the air flow after the shock and, in consequence, the total pressure on the body.

When the wall is flat, the molecules of air are subjected to no acceleration after having encountered the wall, and the air flow receives no further impulse, so that the total pressure amounts to $p/q = 2 \sin^2\alpha$.

When the wall is curved in the direction of flow, the layer of gas flowing along the wall must follow this curvature, and is subjected to accelerations perpendicular to the wall, which gives rise to additional pressures in the case of concave walls and to drops in pressure on convex walls. For a constant radius of curvature, one can, for example, calculate the total pressure on a lens-type aerofoil section to be

$$p = \rho v^2 \sin^2\alpha \left(\frac{3}{2} - \frac{1}{2} \frac{\sin^2 \alpha_s}{\sin^2 \alpha}\right)$$

and on an ogival aerofoil section to be

$$p = \rho v^2 \sin^2\alpha \left(\frac{4}{3} - \frac{1}{6} \frac{1 - \cos \alpha_s \cos \alpha + \sin^2 \alpha_s}{\sin^2 \alpha}\right)$$

wherein α_s represents the local angle of incidence of the surface element located furthest forward. In this case, the pressures therefore diminish very rapidly, from the Newton value at the leading edge of the body towards the rear, and already disappear on the lens-type aerofoil section when the still positive local angle of incidence amounts to $\alpha_s / \sqrt{3}$, and a little later on the ogival aerofoil section, at $\alpha_s / \sqrt{8}$. At these locations, the flow breaks away from the surface of the body, so that the mean pressures of the air on the curved surfaces are much below what they are on the flat surfaces. Surfaces featuring a negative angle of incidence are of course subjected to no air pressure.

If κ is not equal to unity, the shock layer has a finite thickness in view of the fact that $\Delta\rho/\rho < \infty$, and the shock then arises at an angle of α_{sl}, which is slightly larger than the local angle of incidence α_x, namely

$$\frac{\alpha_{sl}}{\alpha_x} = \frac{\kappa + 1}{2}$$

whence there result somewhat higher shock pressures

$$p/q = (\kappa + 1) \sin^2 \alpha_x .$$

As we have seen, the particular laws to which the aerodynamic forces obey at very high Mach numbers lead to very interesting technical consequences.

Fig. 26 presents the polar curves, plotted according to the above relations, of a flat plate of infinite thinness, a wedge-type aerofoil section with a flat pressure side and a thickness amounting to 1/20 of the wing chord in the second third of this chord, and finally of a symmetrical biconvex lens-type aerofoil section (built up of two identical arcs) likewise having a thickness amounting to 1/20 of the chord. In the domain of Mach 1 to 5, one can apply the linear variation of the aerodynamic forces in function of the angle of incidence of the surfaces under consideration (Ackeret's relation) ; here the positive pressures on the surfaces directed against the wind and the negative pressures on the surfaces featuring negative incidence are of the same order of magnitude, and the biconvex aerofoil sections have, as is known, better lift/drag ratios ; in the Newton domain, on the other hand, where the aerodynamic forces vary with the square of the local angle of incidence and the pressures disappear in the " shadow " of the wind, the plano-convex aerofoil sections (*e.g.* the flat-surfaced wedge-type section) are distinctly superior. In the domain of angles of incidence superior to the front " cutting " angle of the wedge-type aerofoil section, this section is even as good as the flat plate. In this velocity range, furthermore, the wedge-type aerofoil section has the remarkable characteristic that the otherwise very rigid demand for thinnest possible aerofoil sections loses in importance, to such a point as to allow, in the limit case, for an aerofoil thickness such that the upper surface of the wing is situated entirely within the "shadow" of the wind.

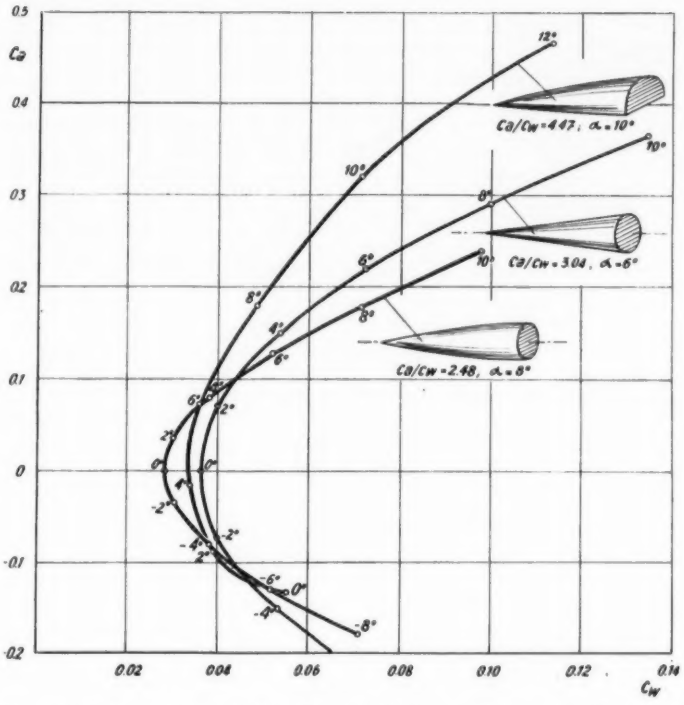


Fig. 27 : Polar curves of bodies of same thickness and frontal area, placed obliquely to the direction of flow (cone, ogive and semi-ogive in a flow governed by gas dynamics) for a Mach number $v/a = \infty$. (Air force coefficients referred to frontal area.)

The inferiority of the biconvex section in comparison to the plano-convex section within the velocity range under consideration here, partly arises from the fact that superior angles of incidence lead to inferior lift/drag ratios, and also from the circumstance that, as the pressure varies with the square of the angle of incidence, the large angles of incidence of the forward elements of the aerofoil sections make themselves more noticed than the smaller angles of incidence of the rear elements ; the result is therefore a lift/drag ratio which is inferior than in the case of the average angle of incidence of the flat lower side of the plano-convex aerofoil section. Besides this, the inferiority of the lens-type section arises from the fact that, all conditions being the same, the curved surfaces are subjected, owing to the centrifugal effect, to lower normal pressures but to approximately the same frictional forces as the flat surfaces of wedge-type sections, so that larger surfaces are necessary for obtaining the same amount of lift, the result of which is not only greater weight, but also higher frictional forces.

In principle, these considerations may also be extended from aerofoil sections to bodies exposed to three-dimensional flow.

Fig. 27 presents the polar curves of three bodies placed in a three-dimensional flow ; they have the same frontal area and the same height, and their configuration would be suitable for a fuselage nose.

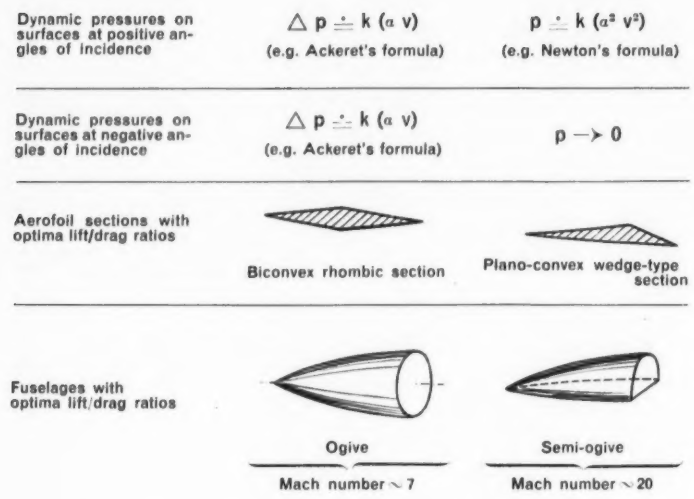

Dynamic pressures on surfaces at positive angles of incidence
△ p ≐ k (α v)
(e.g. Ackeret's formula)
p ≐ k (α² v²)
(e.g. Newton's formula)
Dynamic pressures on surfaces at negative angles of incidence
△ p ≐ k (α v)
(e.g. Ackeret's formula)
p → 0
Aerofoil sections with optima lift/drag ratios
Biconvex rhombic section
Plano-convex wedge-type section
Fuselages with optima lift/drag ratios
Ogive
Semi-ogive
Mach number ∼ 7
Mach number ∼ 20

Fig. 28: Favourable speed range of biconvex and plano-convex supersonic flying bodies.

Whereas the cone and the ogive are approximately equivalent as regards lift/drag ratio, the semi-ogive, engaged at its flat cross-section, reveals a considerable superiority, having an optimum lift/drag ratio of $1/\epsilon = 4.12$. This circumstance is of decisive importance in designing the fuselage of a high-speed rocket aircraft. It teaches us that, at high Mach numbers, the pointed or cutting forward extremity of flying bodies must feature such a form that the pressure side of the wing (which furnishes the lift) is not curved in the direction of flow and that the upper part consists as much as possible of surfaces " sheltered " from the wind, whereby the inevitable remaining surfaces of the upper part, of which the incidence is still positive, should feature a convex curvature following the direction of flow.

There exists considerably less clarity in connection with the problems of the boundary-layer temperature and transmission of heat to the walls at very high Mach numbers than there does at moderate Mach numbers ; and these problems are very delicate.

Although it seems that, because the molecular oscillations and the dissociation begin to make their effects felt, the boundary-layer temperature is always limited to a magnitude of a few thousands of degrees, it must nevertheless be taken into account that the transportation of heat to the walls by dissociated molecules, which recombine on these walls, can be very high. All the same, only the aircraft surfaces featuring positive angles of incidence are submitted to this " heating, " and it must still be examined as to what point the heat transmitted by convection can be restituted to the ambient medium, by special strongly-heated radiation surfaces, for example, eventually with the aid of non-stationary phenomena. Fig. 28 presents diagrammatically the favourable flying-speed ranges of biconvex and plano-convex flying bodies.

3. *Great Flight Altitudes.* Like gas dynamics, aerodynamics is based on the supposition that the medium under consideration is continuous ; for a molecular mean free path of 10^{-7}m for air at sea level, compared with the dimensions of technical bodies, this supposition seems to be justified.

But already at 40,000 m altitude ,the molecular mean free paths attain over 10^{-5} m, and are about equal to the thickness of the laminar boundary layers ; at 120,000 m altitude they amount between to 1 and 10 m, thus being of the same order as the dimensions of the aircraft ; and at 200,000 m, they run into kilometres.

From the mass of the gas molecules colliding per second with the unit of area of a flat plate

$$\bar{\rho} = \frac{\rho}{2\sqrt{\pi}} \cdot c_H \left| e^{-\frac{v^2}{c^2_H} \sin^2 \alpha_x} + \frac{v}{c_H} \sin\alpha_x \left(2 \int_{x=o}^{\frac{v}{c_H} \sin \alpha_x} e^{-x^2}\, dx \pm \sqrt{\pi} \right) \right|$$

wherein ρ is the density, $c_H = \sqrt{2\,g\,R\,T}$ the most probable molecular velocity, v the flying speed and α_x the local angle of incidence, one easily calculates the quantity of heat transmitted to the plate, which one can, for example, make equal to the radiated heat. In this way one obtains the interesting Fig. 29, giving the temperature of the wall T_w of an aircraft at 100,000 m versus the local angle of incidence and the Mach number. The resultant wall temperatures, which are always moderate, would be still lower at greater altitudes, but higher at lower altitudes.

As soon as the aerodynamic forces are known, such as the normal pressures p, friction of the air τ, one can calculate them through the medium of the following relations :

$$\frac{p}{q} = \frac{i_{pH} + i_{pR}}{q} \; ; \; \frac{\tau}{q} = \frac{i_\tau}{q}$$

$$\frac{i_{pH}}{q} = \mp \sin\alpha_x \frac{c_H}{v} \frac{e^{-\frac{v^2}{c^2_H} \sin^2 \alpha_x}}{\sqrt{\pi}} + \left(\sin^2 \alpha_x + \frac{1}{2} \frac{c^2_H}{\sqrt{\pi}} \right) \left(1 \mp \frac{2}{\sqrt{\pi}} \int_{x=o}^{\frac{v}{c_H} \sin \alpha_x} e^{-x^2}\, dx \right)$$

$$\frac{i_{pR}}{q} = + \frac{\sqrt{\pi}}{2} \frac{c_R}{v} \frac{c_H}{v} \frac{e^{-\frac{v^2}{c^2_H} \sin \alpha_x}}{\sqrt{\pi}} \mp \frac{\sqrt{\pi}}{2} \frac{c_R}{v} \sin\alpha_x \left(1 \mp \frac{2}{\sqrt{\pi}} \int_{x=o}^{\frac{v}{c_H} \sin \alpha_x} e^{-x^2}\, dx \right)$$

$$\frac{i_\tau}{q} = + \cos\alpha_x \frac{c_H}{v} \frac{e^{-\frac{v^2}{c^2_H} \sin^2 \alpha_x}}{\sqrt{\pi}} \mp \sin\alpha_x \cos\alpha_x \left(1 \mp \frac{2}{\sqrt{\pi}} \int_{x=o}^{\frac{v}{c_H} \sin \alpha_x} e^{-x^2}\, dx \right)$$

The upper signs refer to the elements featuring negative angles of incidence, and the lower signs to the elements placed at positive angles of incidence. Apart from the already defined values, one finds in these relations $c_R = \sqrt{2\,g\,R\,T_w}$, which is the most probable diffuse molecular velocity after collision with the wall, the latter featuring the temperature T_w deg. K.

For high values of v/c_H, i_{pH}/q tends towards $2\,sin^2\alpha$ and i_{pR}/q towards zero, so that the old formula of Newton, $p/q = 2sin^2\alpha$, applies again in this case, as it does in gas dynamics at high Mach numbers.

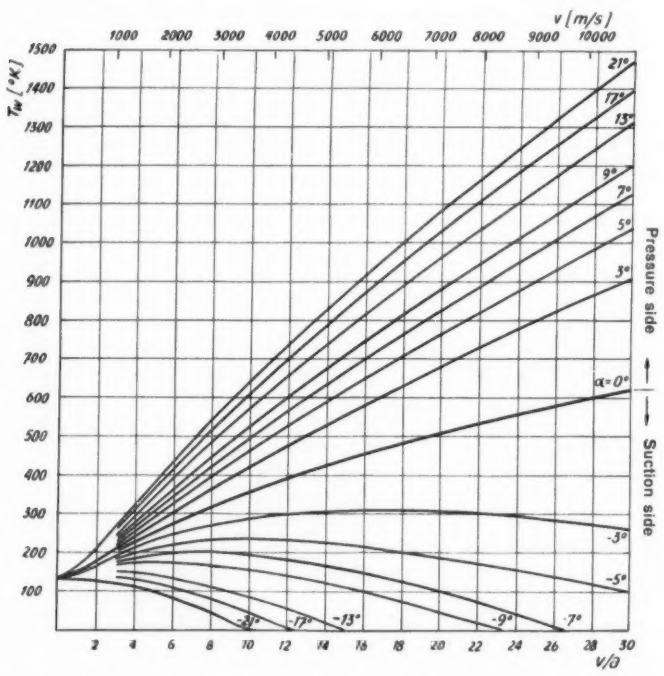


Fig. 29: Wall temperature T_w of a flat plate in an atmosphere composed of 86 per cent. N_2 and 14 per cent. O_2, with a density $\rho = 10^{-7}$ kg. sec²/m⁴ (thus in flow domain governed by gas kinetics), for different flying speeds v/a and different angles of incidence.

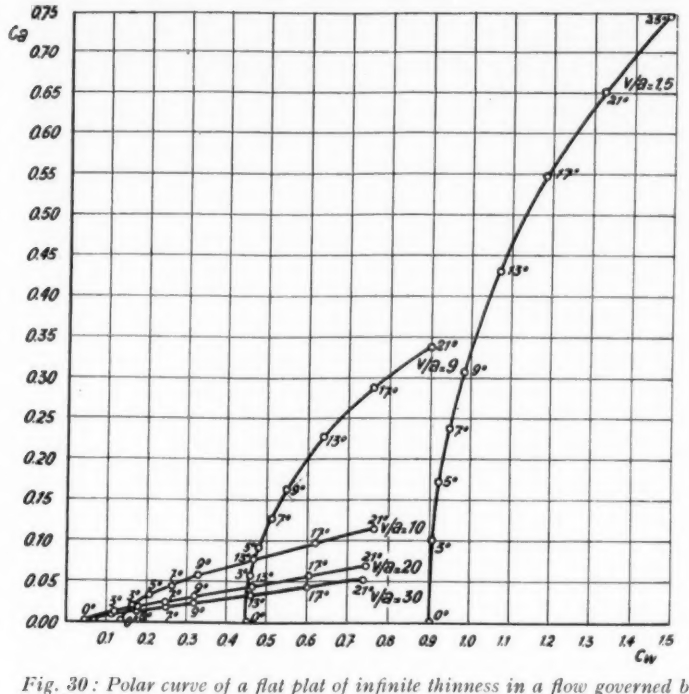


Fig. 30 : Polar curve of a flat plat of infinite thinness in a flow governed by gas kinetics, for different flying speeds.

For $v = 0$, there result the familiar relations of the kinetics of inert gases.

For $a = 0$, there results $\tau/q = \frac{c_H}{v}\frac{1}{\sqrt{\pi}}$, which corresponds quantitatively, in good approximation, to the formulæ utilised for calculating the friction of the gases in highly efficient vacuum pumps.

These formulæ have an exceptionally wide field of application for aerodynamic relations, as they can be used for calculating the pressures normal to the surfaces, the frictional tensions and the transmission of heat, for all Mach and Reynolds numbers and for bodies of all shapes (*e.g.* meteors, missiles, aircraft, vacuum pumps, etc.).

Furthermore, emphasis should be given to the high values assumed by τ/q ; they are of the order of 10^3 superior to those of a continuous flow of gas, and clearly show the appreciable value of the continuous boundary layers arising from the direct collision of the molecules with the walls.

Only the fact that, at the altitudes under consideration, the dynamic pressures become extremely small, enables flight to be accomplished at these altitudes. For example, Fig. 30 shows the polar curves plotted from the relations presented above, for a flat plate of infinite thinness and for Mach numbers ranging between 1.5 and 30.

(Continued in the next issue)

Erratum : Title picture to Part I of this article (in September issue) : rocket is fuelled with gas oil and liquid oxygen, and produces 1 tonne of thrust.

A New Controllable-Pitch Propeller

By G. LYONNET, B.Sc., Paris.

The Compagnie Générale pour l'Equipement Aéronautique, of Paris, formed through the merger of the Chauvière propeller firm and the Olaer component manufacturing concern, has been working on controllable-pitch propellers for many years. As early as in 1936, the Chauvière concern had developed a high-speed pneumatic pitch-change mechanism which took its power directly from the engine and was designed for decelerating the diving speed.

Tests flights with this propeller were most encouraging, and above all confirmed the soundness of the fundamental constructional principles. Moreover, they revealed that two different velocities were indispensable in the pitch-change process : a slow pitch change in order that the operation should proceed evenly when regulated automatically, and a very fast one to be able to change over to reverse pitch without causing dangerous overspeeding of the engine whilst the " windmilling " zone of the propeller was crossed.

As the pneumatic pitch change gave rise to difficulties during constant-speed operations, the C.G.E.A. devised, in 1939, an electrically-operated mechanism, which likewise took its power directly from the engine. Though the war and the occupation presented many obstacles, a prototype was nevertheless completed and test flown in 1942. However, it was discovered that propellers embodying such a complex pitch-change principle could only be safe if used in conjunction with a specially-constructed automatic apparatus functioning with absolute reliability.

The design and construction of automatic and auxiliary equipment, such as relays, contacts, controls, and so forth, was undertaken immediately, but post-war difficulties presented severe set-backs and it was not until 1946 that the *Chauvière electric reversible-pitch propeller* was completely developed. Rigid acceptance trials and flight tests with Bloch 152 and Bloch 161 aircraft have since

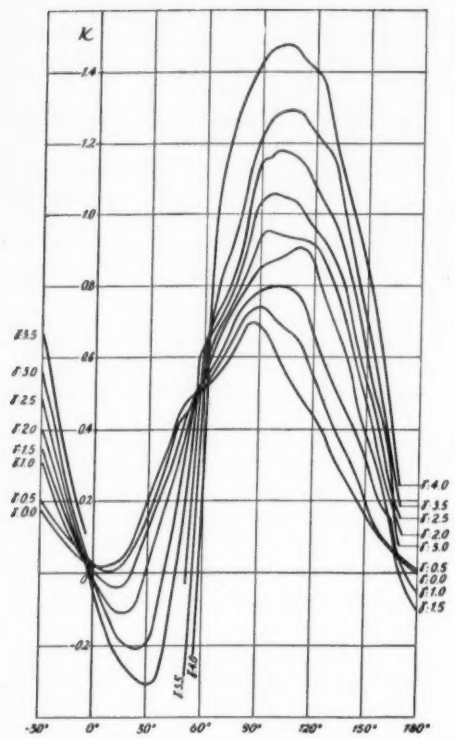


Fig. 1: Power absorbed by C.G.E.A. 521 three-blade propeller versus blade angle and advance ratio (γ). K = power coefficient

$$K = \text{advance ratio} = \frac{v}{nD}$$

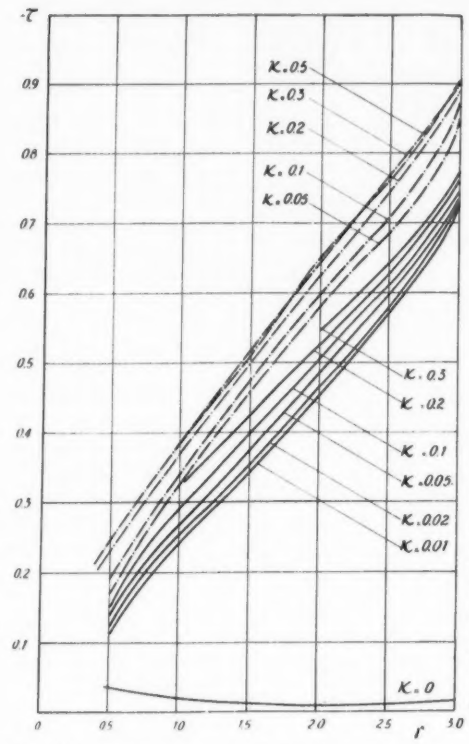


Fig. 2: Braking force of C.G.E.A. 521 three-blade propeller versus advance ratio (γ) and power coefficient. T = thrust coefficient.

Dotted line: braking with trailing edges
Full line: braking with leading edges

proved that the new type of propeller compares most favourably with all competitive models of similar design.

The aerodynamic problems were energetically pursued whilst the mechanical development was proceeding. It would be superfluous to explain here the various advantages of reversible-pitch propellers, but it is perhaps profitable to remember that propeller braking can be achieved either by diminishing the blade pitch until it assumes a negative angle, or by increasing the blade angle to between 90 and 180 degrees. In the first case it is the leading edges which meet the air, and in the second case the trailing edges. Both methods have certain advantages and disadvantages. Judging from Figs. 1 and 2, braking with the trailing edges is more effective than with the leading edges.

During braking with the leading edges, the blades cross the "windmilling" zone, which has to be passed through as quickly as possible in order to avoid engine overspeeding. However, the angle of pitch-change is very small. Furthermore, it is not possible to balance the blades as regards bending and twisting stresses merely by incorporating a construction angle, since the centrifugal forces in the braking position give rise to an increase in the aerodynamic forces. The twisting stresses must therefore be compensated by counterweights, which cause the weight and tensile stresses in the blade root to be increased.

Braking with the trailing edges calls for a large engine torque moment; for while the blades pass through the feathered position, they can stop the engine. This critical zone must therefore be passed through very quickly. Additionally, the angle of pitch change is much larger than in the first case, so that the velocity of pitch change must necessarily be very high. This time the blades' bending and twisting stresses can be balanced merely be incorporating a construction angle, because the centrifugal forces and aerodynamic forces in such a case exercise a contrary effect, whether the pitch be normal or at a reverse angle. This solution therefore leads to thinner and lighter blades.

The Chauvière electric reversible-pitch propeller fulfils the following functions:—

a) Manual adjustment of pitch angle with engine running and at standstill.

b) Constant-speed operation during take-off and flight.

c) Immediate feathering in case of engine failure.

d) Rapid reversal of pitch to a pre-selected favourable braking position in diving or in landing run, simply by setting the throttle below idling power.

The total weight of the ten-foot-diameter three-blade propeller used in conjunction with the Bloch 175 twin-engined aircraft is 354 lbs., being built up of the following:—

Hub	123 lbs.
3 duralumin blades	112 lbs.
Pitch-change mechanism	84 lbs.
Spinner	12 lbs.
Automatic and auxiliary equipment	23 lbs.

Description and Function

The design of the hub and blades is more or less the same as that used in conjunction with the majority of classical propellers. The rotation of the blades is accomplished with worm drives located in the hub, parallel to the propeller shaft, meshing with screw wheels at the blade roots. (Fig. 3.)

As already stated, the pitch-change mechanism takes its power directly from the engine; this is done by electro-magnetic clutches. The upper part of Fig. 4 presents this mechanism diagrammatically. On the propeller shaft are two concentric wheels, (1) and (2), which each have the same number of teeth. Wheel (1), called the "driving wheel," is keyed on to the shaft, and wheel (2), which is the "loose wheel," turns freely on the shaft; it additionally comprises a second row of teeth which mesh with wheels keyed on to the worm drives of the blades. Two other toothed wheels, (3)

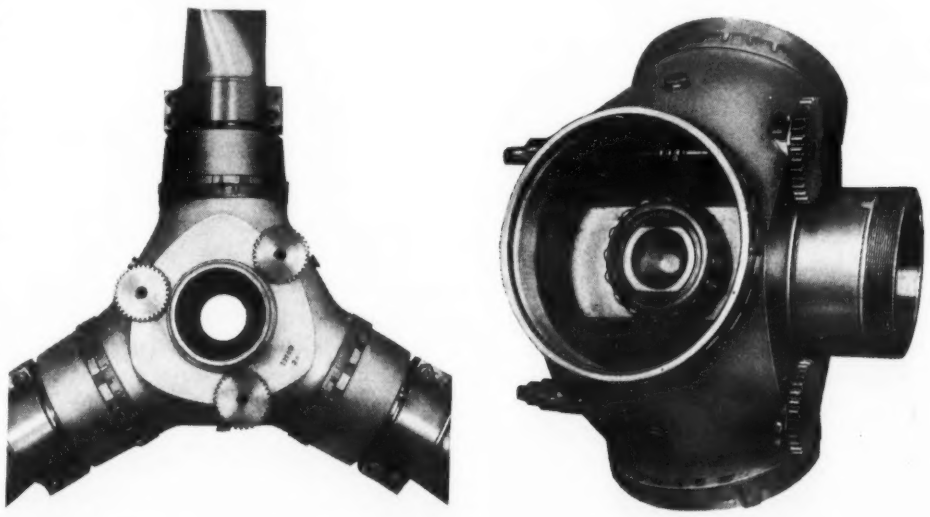


Fig. 3: Propeller hub seen from front and side. Blades are rotated through worm drives meshing with screw wheels at the blade roots.

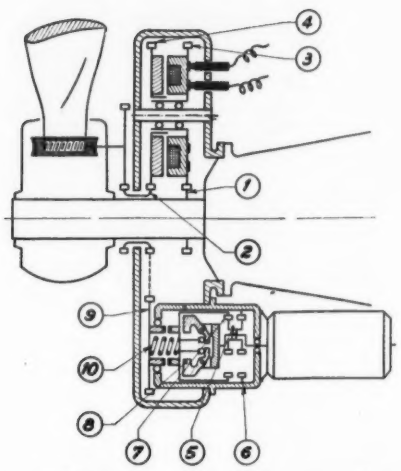


Fig. 4: Diagram of how blades are adjusted either by one of the four electro-magnetic clutches (above) or by the auxiliary electric motor (below).

1 : Toothed wheel keyed on to shaft
2 : Free wheel with double row of teeth
3 : Rear row of teeth with electro-magnet and brushes
4 : Wheel mounted on armature (different number of teeth than wheel 3)
5 : Planet wheel with double row of teeth
6 : Fixed ring with interior toothing
7 : Movable gear wheel with interior toothing
8 : Centrifugal weights for clutch
9 : Electric motor drive (1 : 400 reduction)
10 : Return spring of centrifugal force clutch

and (4), turning freely about a shaft fixed into a light alloy crank-case, mesh respectively with wheels (1) and (2). An ingenious tooth cutting procedure has enabled the number of teeth on wheels (3) and (4) to differ, according to the specific application, by one to eight teeth, without being detrimental to the quality of the meshing. Wheel (3) carries a ring-shaped electro-magnet (fed by brushes) and wheel (4) an armature situated opposite to the magnet. This system is presented in cross-section in Fig. 5.

When the blade pitch remains unchanged, wheels (3) and (4) rotate freely but not at the same speed in view of the difference existing between the number of teeth they feature. When the magnet is energised, wheels (3) and (4) are coupled together and the relative movement due to the different toothing is consequently at the disposal of the blade pitch-change procedure.

The case housing the pitch change mechanism contains four of these clutches, which differ only as regards the arrangement and number of the teeth (Fig. 6). Two of these clutches cause the blades to rotate at a speed of 3 deg./sec., the first one increasing the angle of pitch and the second one decreasing it. They are used for manual and automatic regulation. In the latter case the regulator closes the power circuit of one or the other clutches through the medium of relays. Here the regulation is extremely accurate, since its speed is very low and the delay in response is short.

The two other electro-magnetic clutches feature a much greater difference in toothing, and consequently rotate the blades at a speed of 30 deg./sec. in either direction. They are for the rapid pitch change into feathered position in the case of engine failure, and also for aerodynamic braking with the propeller when diving or after landing.

Since the rate of pitch change, as can be seen, is always proportional to the engine r.p.m., the clutches of course work too slowly when the r.p.m. is very low (*e.g.* in the case of strongly braked windmilling) and they are quite ineffective when the engine is at a standstill. For this reason an electric motor (24 volts D.C., 1/3 H.P., 8,000 r.p.m.), rotating in both directions, has been incorporated ; it comes to the rescue as soon as the propeller r.p.m. is less than 500. This auxiliary motor, together with its planet reduction and a centrifugal clutch, is also fastened to the casing as a self-contained unit. Its mode of function can likewise be seen from Fig. 4.

A planet wheel with a double row of teeth (5), located on the cranked shaft of the electric motor, meshes whilst rotating with the fixed interior toothing (6) and thereby turns the movable interior row of teeth (7) at the greatly reduced ratio of about 1 : 400. The centrifugal clutch consists of two centrifugal weights (8) which, as soon as they rotate at the r.p.m. of the auxiliary motor, cause a spring-loaded claw clutch (10) to move backwards. In this way the otherwise freely-turning toothed wheel (9) can cause to turn, via an intermediary spur wheel, the double-row wheel (2) at the r.p.m. of (7), and thereby turn the pitch-change worm and wheel reduction. The velocity of pitch-change accomplished with the electric motor corresponds roughly to that resulting from the slowly-moving electric clutch (3 deg./sec.).

Besides altering the blade pitch when the engine is stopped, this system also makes possible an extremely rapid change-over to feathered position in the case of engine failure (within 1½ to 2 seconds). The root of the matter is that the toothed wheel (9), which only turns at about 20 r.p.m. (8,000 : 400), may be regarded as being almost at a standstill when compared with the propeller r.p.m., and also because the auxiliary motor, in view of its high planet reduction ratio, can under no circumstance be made to rotate in a direction contrary to that selected.

Meanwhile, this manœuvre may not be utilised at full engine r.p.m. since its effect would be too sudden. In consequence, the feathering procedure is completed in two phases. First of all, the " windmilling " of the recalcitrant engine is braked by the electric clutch for rapid pitch increase, and only afterwards, once the r.p.m. has diminished to a certain magnitude, is the auxiliary motor switched on. This change-over is carried out by an automatic switch device, which is described in Fig. 7. Inversely, if an

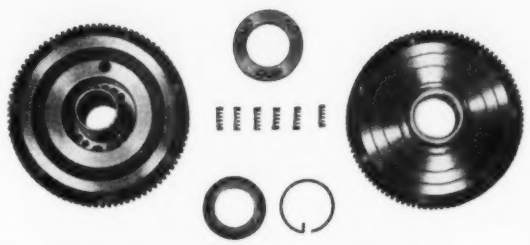


Fig. 5 : Components of an electro-magnetic clutch.

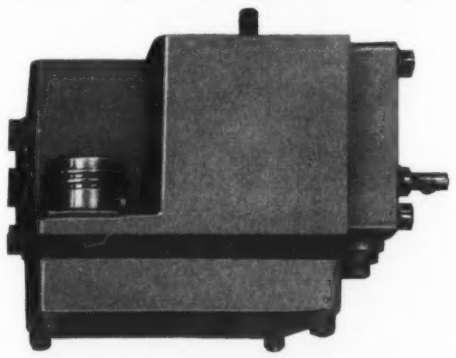
engine has to be brought from feathered position back to normal operation, the auxiliary motor first adjusts the blades until the engine windmills, and subsequently leaves the further adjustment to the electric clutch for rapid pitch-change. Here, too, the automatic switch device intervenes.

This automatic device is presented diagrammatically in Fig. 8. When the propeller blades have to be feathered, a contact controlled by centrifugal force (11) actuates

Fig. 6 : The pitch-change mechanism casing contains four clutches (for rapid or slow blade rotation to coarse or fine pitch), the electric motor (above) and the limiting control (below).

a relay at a suitably preselected r.p.m. The centrifugal-force contact is driven by the engine via a flexible shaft. The reverse procedure, namely the return to pitch angles for normal flight, was more difficult to solve. As soon as the propeller begins to windmill, the auxiliary electric motor has to be stopped, since a return to feathered position would otherwise arise. For this reason the following solution was found.

Fig. 7 : The automatic switch device is separate from the pitch-change mechanism casing and connected with the engine via a flexible shaft.



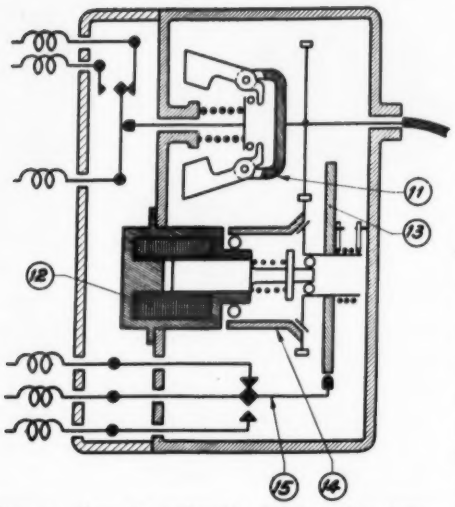


Fig. 8: How the automatic switch device functions.

11 : Centrifugal contact, driven by engine, for feathering propellers
12 : Electro-magnetic friction coupling
13 : Cam controlling contact 15
14 : Engine-driven counterpart to friction coupling
15 : Contact for returning from feathered position

When the electric motor is switched on, the coil (12) of an electro-magnet is simultaneously energised, thereby creating a friction coupling between a cam (13) and the wheel (14) connected with the engine. As soon as the electric motor has sufficiently reduced the pitch and the propeller has begun to windmill, the cam (13) turns, switches off the electric motor through a contact (15) after it has accomplished only a quarter of a revolution, and switches the electro-magnetic clutch on. The friction coupling between (13) and (14) then continues to slide until the propeller r.p.m. is sufficiently high to actuate the centrifugal-force contact (11), which in turn interrupts the flow of current to the coil (12). At this point, a spring hauls the cam (13) back into its original position.

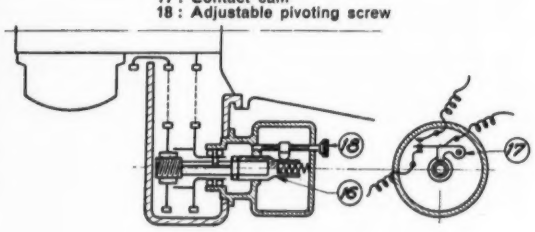
In conclusion, a few words should be said about the means for limiting the blade positions. The blades can be made to assume all angles of pitch between two limiting values. Their limit positions are regulated by electric contacts which, at a prescribed time, either cause a clutch or the electric motor to intervene. For reasons of safety, there are also mechanical stops arranged inside the hub, which prevent the limit positions from being exceeded in an eventual case of the automatic system failing. Between the two limit positions there is, moreover, a specified blade position which is likewise regulated by an electric contact.

When braking is accomplished with the leading edges, feathered position and reverse pitch form the two limit positions ; the medium position corresponds to fine pitch.

When braking is accomplished with the trailing edges, however, the limit positions are represented by the fine pitch and reverse pitch, whilst the feathered position lies in the middle. This solution therefore presents the valuable advantage that it enables a mechanical stop to be used for limiting the fine pitch, consequently making it possible to return to normal flight position even if the normal control fails.

Fig. 9: System for limiting blade pitch.

16 : Sliding switch system moved by differential threaded socket
17 : Contact cam
18 : Adjustable pivoting screw



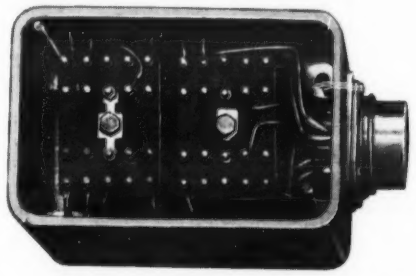


Fig. 10: Relay box with high-capacity, deep-core relays for selecting electro-magnetic clutches.

Fig. 11: Cockpit equipment includes a four-way switch, with unstable "pitch-increase" and "pitch-decrease" positions (switch moves back to neutral as soon as pilot loosens his grip on the contact), and stable self-control and feathering positions. In the self-control ("automatique") position, the blade pitch is controlled either by the regulator or the throttle lever.

The electric limit contacts are actuated by a sliding switch system which is mechanically driven and translates the blade pitch movement into linear motion ; these contacts can be made to move in both directions independently of one another. In a simple manner, Fig. 9 shows this sliding device (16), moved by a threaded socket, which is differentially driven by the free-wheeling toothed wheel and also by the fixed tooth wheel on the propeller shaft, thereby operating cams (17) which in turn operate the contacts. The cams are located adjustably on screwed spindles (18) ; the entire system is attached as an enclosed unit to the casing of the pitch-change mechanism.

As regards the control equipment in the cockpit, in addition to the four-way switch shown in Fig. 11, there is a specially-designed throttle lever with which the pilot can also "brake" at will. If this throttle lever is pulled back to below idling power, it actuates the two rapid pitch-change clutches via switches. If the pilot pulls it still further backwards, the braking action becomes greater ; conversely, it is reduced as the lever is pushed forward. After the throttle lever has been pushed forward to above the idling position, the propeller begins to produce positive thrust again.

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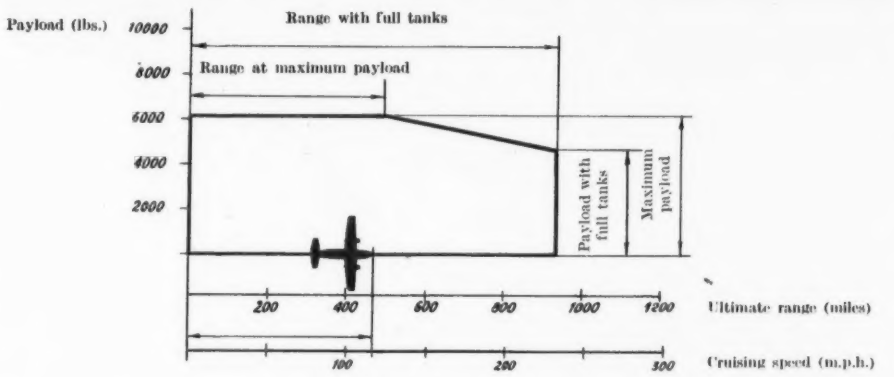
Twin-Engined Commercial Transports

This article continues our series of reviews of present-day aircraft types, which began last March. Whereas earlier ones were restricted to service and personal aircraft, the present article represents the first of a comprehensive survey of all commercial transport aircraft. A review of the types having three, four and more engines will follow.

If, in considering present-day aviation, we could be "from hope and fear set free" — without hope for an era of private flying, without fear of a new era of aerial warfare — then the commercial transport would command our attention as *the* aircraft of today. But even when we speak of commercial transport aircraft, our thoughts unconsciously become affected by facts, hopes and a certain degree of forgetfulness . . . As if all the new types of which we are daily reminded by high-pressure publicity campaigns had already given proof of their reliability in actual airline service and as if the last models of the historical first all-metal airliner, the Junkers F-13, which are still being operated in Southern Brazil, had already a long time ago found niches in museums !

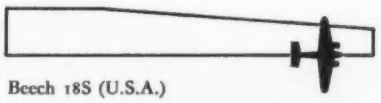
The present group of today's transport aircraft, and that which is to follow in the next issue, does not pretend to be an extremely objective snapshot of types being used by all the world's airline companies in autumn, 1948 ; perhaps it will be able to boast as much in two to three years' time. For we have left out a number of obsolete types — though not always with absolute justification, we have included among these all single-engined designs — and listed others which are under test and



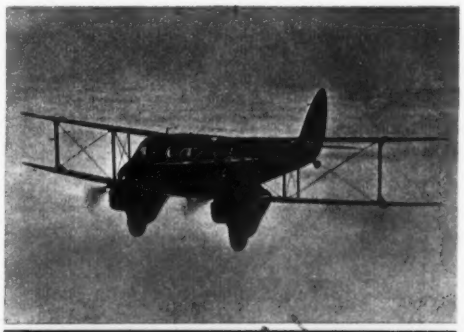
The black silhouettes give an idea of the size and configuration of the aircraft, and their distance from the base line on the left indicates the recommended cruising speed. The relation between range and payload is discernible from the trapezoidal diagram : its maximum height indicates the maximum payload permitted by the available volume (calculated at 170 lbs. per passenger and 10 lbs./cu.ft. cargo space); the greatest width of the diagram corresponds to the maximum range in still air, if every drop of fuel which can be carried in the normal tanks, is used up. All data are based on unified assumptions; figures released by the manufacturers are suitably converted and, where lacking, replaced by estimates.

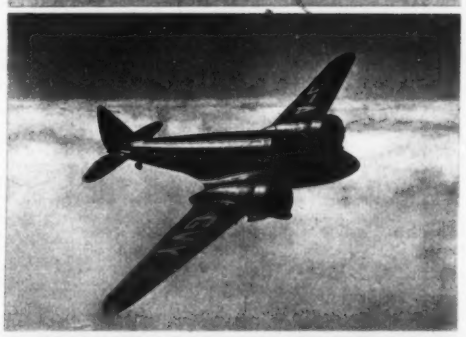
De Havilland DH.89A "Dragon Rapide" (G.B.)

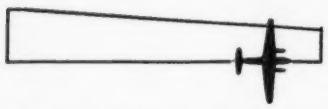
Airspeed AS.65 "Consul" (G.B.)



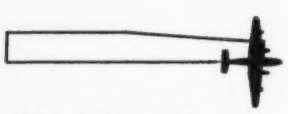
Beech 18S (U.S.A.)







De Havilland DH.104 "Dove" (G.B.)



Short "Sealand" (G.B.)

in production, but are not yet to be found on the airline routes.

In this issue we shall restrict ourselves to twin-engined commercial transports, and for the present leave out those three- and four-engined types which, as regards size and seating accommodation, enter into competition with them. All of these twin-engined aircraft are for short- and medium-range airline operations.

Comparison of the size of the aircraft from the columns "passengers" or "take-off weight" in the table (pages 570-571) reveals an unexpectedly sharp distinction between small feeder-line aircraft seating 6-12 passengers and medium types for continental traffic with 20-40 passengers, galley and air hostess. The only intermediary class is formed by the 14-passenger *Lockheed "Lodestar,"* production of which, however, was not resumed after

Country	Manufacturer or designer	Designation	Power plant Manufacturer and Designation	Take-off power per engine	Dimensions			Passengers [1]	Disposable load		
					Span	Length	Wing area		Cargo volume	Maximum payload [2]	Crew members
				H.P.	ft. in.	ft. in.	sq. ft.		cu. ft.	lbs.	
G.B.	De Havilland	DH.89A "Dragon Rapide"	De Havilland "Gipsy Queen III"	200	48'0"	34'6"	336	6	27	1,290	2
U.S.S.R.	Yakowlev	YAK-8	M. 11	150	45'4"	37'2"	323	6	...	...	2
G.B.	Airspeed	AS.65 "Consul"	Armstrong Siddeley "Cheetah X"	395	53'4"	35'4"	348	6	20	1,220	2
U.S.A.	Beech	18S	Pratt & Whitney "Wasp Junior"	450	47'7"	34'3"	349	7	*c.* 90	2,090	2
G.B.	De Havilland	DH.104 "Dove"	De Havilland "Gipsy Queen 70"	340	57'	39'6"	335	8	89	2,340	2
G.B.	Short	"Sealand"	De Havilland "Gipsy Queen 70"	345	59'	42'2"	353	5	77	1,400	1—2
G.B.	A.V. Roe & Co.	Avro XIX	Armstrong Siddeley "Cheetah XV"	420	56'6"	42'3"	463	6	57	1,590	2
G.B.	Percival	P.50 "Prince"	Alvis "Leonides 501/4"	520	56'	42'11"	365	8	53	1,890	2
France	SNCA du Centre	NC 702 "Martinet"	Renault 12 S.00	450	69'10"	42'0"	495	8	*c.* 70	2,063	2
France	SNCA du Sud-Ouest	SO 95	Renault 12 S.02	575	59'1"	40'5"	403	12	...	2,380	2
U.S.A.	Grumman	G-73 "Mallard"	Pratt & Whitney "Wasp H"	600	66'8"	48'4"	444	8	(300 lbs.)	1,700	3—4
U.S.S.R.	Yakovlev	YAK-16	Chvezov ASch 21	700	*c.* 56'	*c.* 36'	...	10	...	...	2
U.S.A.	Lockheed	L-18 "Lodestar"	Wright "Cyclone 9" or Pratt & Whitney "Twin Wasp"	*c.* 1,100	65'6"	49'10"	551	14	190	4,280	3
U.S.A.	Douglas	DC-3	Pratt & Whitney "Twin Wasp"	*c.* 1,100	95'0"	64'5"	987	21	305	6,265	3
U.S.A.	Consolidated Vultee	"Catalina"	Pratt & Whitney "Twin Wasp"	1,200	104'0"	68'7"	1,400	22	...	4,400	3
Sweden	Svenska Aeroplan	SAAB 90 "Scandia"	Pratt & Whitney "Twin Wasp R-2180"	1,650	91'10"	69'11"	922	32	389	9,330	2—3
G.B.	Vickers Armstrongs	VC.1B "Viking"	Bristol "Hercules 634"	1,725	89'3"	62'2"	882	27	270	7,290	4
U.S.S.R.	Ilyushin	IL-12	Chvezov ASch 82 FN	1,800	104'	70'	...	32	...	...	4—5
U.S.A.	Martin	2-O-2	Pratt & Whitney "Double Wasp CA"	2,100/2,400	93'4"	71'4"	860	40	(3,400 lbs.)	10,520	3
G.B.	Bristol	170 "Wayfarer"	Bristol "Hercules 672"	1,690	108'0"	68'4"	1,487	32	445	9,890	4
U.S.A.	Consolidated Vultee	240 "Convair-Liner"	Pratt & Whitney "Double Wasp CA"	2,100/2,400	91'9"	74'8"	817	40	435	10,870	4
France	SNCA du Sud-Ouest	SO 30P "Bellatrix"	Pratt & Whitney "Double Wasp B43"	2,000	88'3"	62'2"	928	30	423	9,325	4
U.S.A.	Curtiss-Wright	CW-20 "Commando"	Pratt & Whitney "Double Wasp"	2,000	108'1"	76'4"	1,360	40	456	11,360	4—5
G.B.	Airspeed	AS.57 "Ambassador"	Bristol "Centaurus 661"	2,700	115'	80'3"	1,200	40	305	9,850	4

[1] Normal number, provided interior layout includes toilet or (if for more than 20 passengers) galley and stewardess facilities.

[2] Standardised at 170 lbs. per passenger and 10 lbs./cu.ft. freight volume. Data therefore vary frequently from those given by manufacturers.

[3] Only normally built-in tanks.

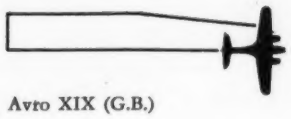
[4] Including crew and oil.

[5] Including removable equipment and all passenger amenities.

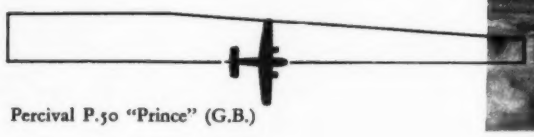
the war. Neither are the 21-passenger Douglas DC-3 and the 22-passenger Consolidated "Catalina" amphibian still in production ; it is rather the Vickers "Viking" and the Swedish SAAB "Scandia," both existing in 24-passenger versions, which represent the smallest types for continental traffic.

Why is it that today no aircraft manufacturer has a twin-engined type for 12-24 passengers to offer ? Before answering this question we had best take a look at the feeder-line aircraft accommodating less than 12 passengers.

At the top of our list stands the *de Havilland "Dragon Rapide"* which, as regards short take-off distance, is superseded only by the Airspeed "Consul," but has only half the latter's engine power. Hence this old biplane is the only type which can be used for feeder



Avro XIX (G.B.)



Percival P.50 "Prince" (G.B.)

Fuel supply [2]	Maximum total [4]	Total weights: Tare weight [5]	Take-off weight	Landing weight	Take-off wing loading	Take-off power loading	Flight performance [6]: Cruising speed	Cruising altitude	Cruising power	Take-off distance over 50-ft. obstacle [7]	ICAO take-off	Landing distance [8]	Service ceiling	Observations
Imp. Galls.	lbs.	lbs.	lbs.	lbs.	lb./sq. ft.	lb./H.P.	m.p.h.	ft.	H.P.	ft.	ft.	ft.	ft.	
76	1,850	3,700	5,550		16.5	13.9	130	1,000	180	1,535	—	1,260	16,700	
...	2,100	3,850	5,950		18.4	20	*c.* 150	...	...	...	—	...	13,000	
156	2,187	6,063	8,250		23.7	9.4	145	10,000	...	1,440	—	825 [9]	18,700	
206 *	2,768	5,732	8,500		24.4	9.45	211	10,000	300	1,650	—	1,390	21,200	
130	2,843	5,657	8,500		25.4	12.5	179	8,000	205	2,370	4,290	2,250	20,000	
120	*c.* 2,100	*c.* 7,000	9,100		25.8	13.2	174	6,600	245	1,680	—	1,875	20,600	Take-off and landing distances as landplane of 8,700 lbs. gross weight.
140	2,981	7,419	10,400		22.5	12.4	174	5,800	...	2,100	—	1,710	19,000	
180	3,065	7,585	10,650		29.2	10.2	177	10,000	260	1,836	3,063	...	24,000	
189	3,605	8,741	12,346		25	13.7	202	9,840	...	...	—	...	24,600	
...	3,572	8,774	12,346		30.6	10.7	221	8,530	390	1,150 [9]	...	...	19,700	
...	3,375	9,125	12,500		28.2	10.4	180	...	330	...	—	...	...	Ceiling of 10,500 ft. on one engine.
198	*c.* 3,000	*c.* 11,000	14,100	Usually the same as the gross weight	...	10.1	180	5,580	...	850 [9]	—	...	16,400	
644 *	6,284	12,216	18,500		33.5	*c.* 8.4	239	15,000	750	1,700	—	...	25,400	
804 *	6,775	18,425	25,200		25.6	*c.* 11.5	194	10,000	630	2,000	—	1,865	23,200	Built under licence in U.S.S.R. with designation Li-2.
1,750 *	11,096	19,404	30,500		21.8	12.7	145	10,000	...	1,210 [9]	—	...	19,500	
638	11,497	20,911	32,408		35.1	9.8	250	10,000	940	1,935	3,690	1,770	28,550	Pressurised cabin if desired.
750	10,750	23,250	34,000	32,500	36.9	9.4	210	10,000	800	2,550	3,600	2,550	23,750	
1,430	...	...	38,000	...	...	10.5	217	8,200	...	1,475 [9]	...	1,700 [9]	...	Ceiling of 9,850 ft. on one engine.
1,000 *	14,079	25,821	39,900	38,000	44.2	9.5/8.3	237	5,000	1,260	1,565	3,510	1,720	33,000	
700	12,414	27,586	40,000	40,000	26.9	11.8	162	5,000	875	2,310	(3,690)	2,310	21,100	
1,000 *	13,700	26,800	40,500	38,571	49.6	9.6/8.5	291	16,000	1,200	...	4,250	2,500	32,000	Pressurised cabin.
700	11,870	29,130	41,000	...	44.2	10.25	261	21,300	990	...	5,575	3,350	...	Pressurised cabin.
1,400 *	...	...	45,000	...	34.1	11.25	227	...	1,340	...	...	...	24,500	
1,000	11,732	35,268	47,000	46,300	39.1	8.7	240	20,000	970	2,640	3,900	2,640	25,000	Pressurised cabin.

* For range (varying according to payload) see graphic presentation ; this is often based on a more economic cruising speed than that given here.

[7] In the case of one engine failing as the aircraft becomes airborne (dashes do not denote that data are not forthcoming, but that the possibility of such a take-off with full load cannot be counted on).

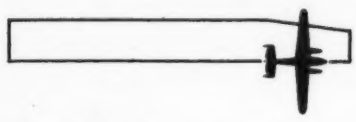
[8] Under normal circumstances, this distance should amount to only 60 per cent. of the runway

[9] Restricted to rolling distance on ground.

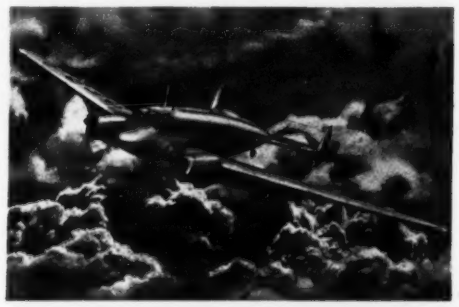
* U.S. Galls.

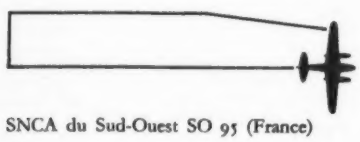
operations from small and primitive airfields. Meanwhile, this leads us to ask why so-called feeder aircraft are being built today, which are capable of operating from large airports only. Other stop-gap solutions for feeder traffic are the converted *"Consul"* and *Avro XIX* military communication aircraft, whose low purchase price manages to offset their high fuel consumption. The only small feeder aircraft of American origin, the *Beech 18S*, also has engines of over 400 H.P., but justifies this extra item with a seventh passenger seat and a high cruising speed. It is still being produced today. Another aircraft which is a little larger and also quite fast is the *"Martinet,"* built by the French SNCA du Centre concern, which was originally a copy of the German Siebel Si 204 courier aircraft.

But which modern types are expected to take the place of these pre-war and wartime aircraft ? The question is still unsolved. It so happens that the demands for short take-off distances have been unexpectedly but rightly made stricter by a safety regulation in the operating standards drafted by ICAO : the gross weight at take-off shall not exceed a value such that, with the critical engine inoperative, the aircraft will attain a height of 50 feet before passing over the end of the take-off area. In this case it should also be possible to bring the aircraft to a standstill before reaching the end of the runway. In addition to this ICAO regulation there comes, of course, the desire of the airline companies for increased economy as compared with pre-war types.

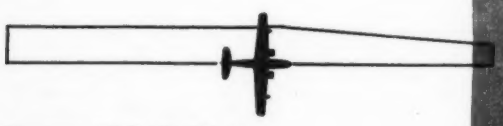


SNCA du Centre NC 720 (France)

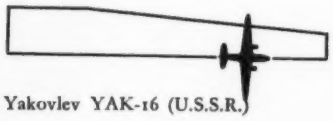




SNCA du Sud-Ouest SO 95 (France)



Grumman "Mallard" (U.S.A.)



Yakovlev YAK-16 (U.S.S.R.)

Lockheed "Lodestar" (U.S.A.)

Our list features three feeder landplanes developed since the war. The take-off runway length calculated according to the ICAO specification is given for two of them : 4,290 ft. for the *de Havilland "Dove,"* an aircraft designed for particularly economic operations; and 3,063 ft. (calculated) for the *Percival "Prince."* ICAO take-off conditions can likewise be fulfilled by the French *SO 95* at full take-off weight, but there is no reason to be over-optimistic about the required runway length. Even ICAO specifies a runway length of 3,500 ft. for Class G, the smallest feeder airport category. An attempt to judge the future prospects of feeder traffic would be out of place in this article, but we cannot help observing that there is not a single twin-engined aircraft enabling such operations to be carried out under ICAO conditions if the airfield is not at least of Class G dimensions.

Since short-line traffic for communications between certain remote districts and the civilised world is frequently of vital importance, repeated attempts to overcome the shortage of airfields in these areas are being made with flying-boats and amphibians. Among these may be mentioned the eight-passenger *Grumman "Mallard"* and the newly-developed *Short "Sealand"* for five passengers.

We finally come to the Soviet feeder-line transports, the *Tcherbakov Tche-2* (not in the table) and *Yakovlev YAK-8* for six passengers, and the *Yakovlev YAK-16* for ten passengers, on which it is impossible to comment in view of the dearth of relevant information.

The rigid ICAO take-off requirements have also complicated the design of larger twin-engined aircraft, which would have been able to replace the Lockheed "Lodestar," for instance. There was the *Lockheed 75 "Saturn,"*[1] a 14-passenger transport which Lockheed Aircraft Corp. developed soon after the war. Likewise requiring a runway length of about 3,000 ft., this aircraft would only have been able to serve a few cities which were not already being served by faster and more economic aircraft. Lack of demand on the

[1] Cf. "Interavia Review" No 6, Vol. I, pp. 41-47.

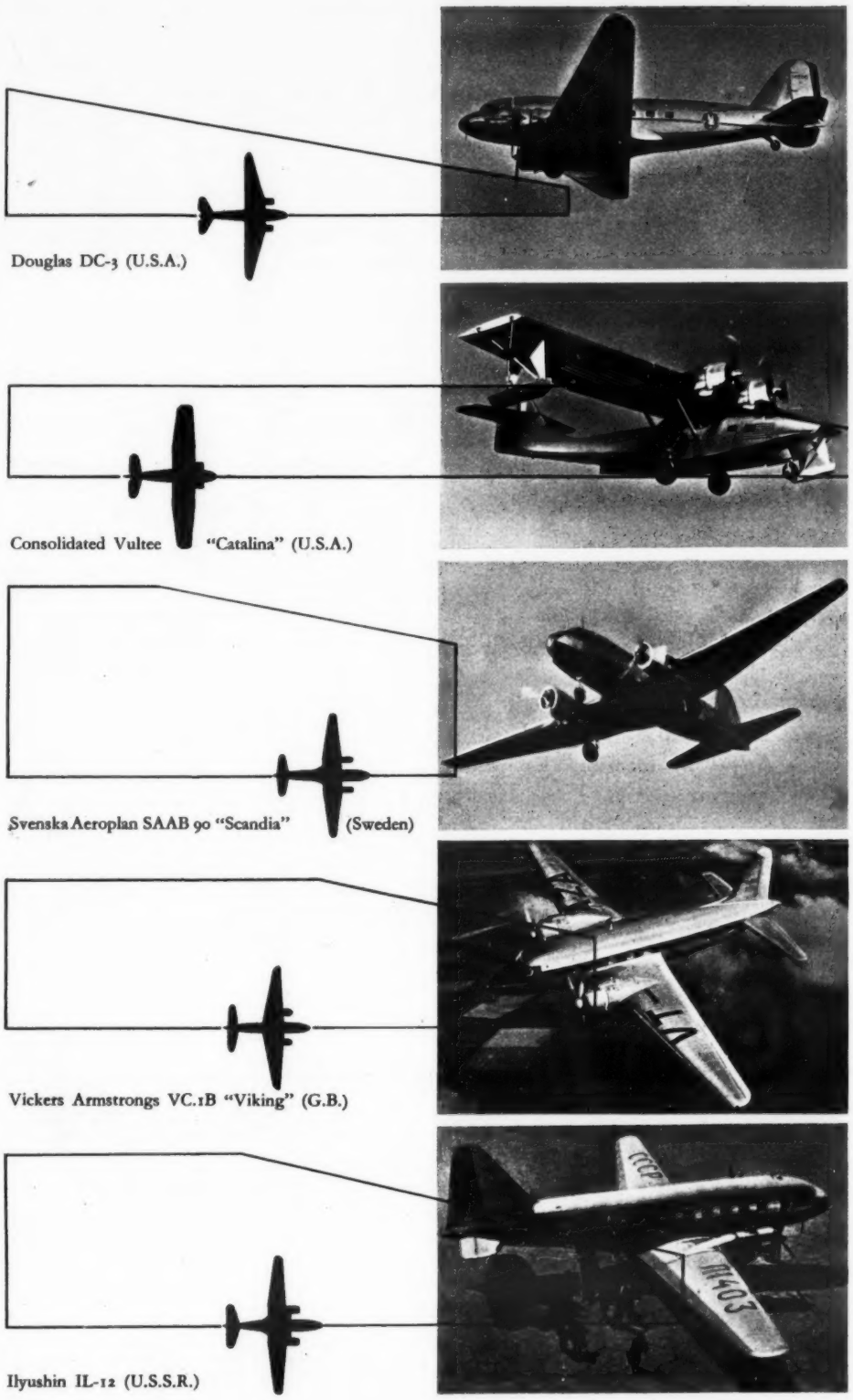
part of the airline companies caused the manufacturers to abandon their production plans.

Among the types which accommodate over 20 passengers and feature a galley and stewardess facilities, the famed *Douglas DC-3* is the smallest, oldest and the most flown. Up to a short time ago, 80 per cent. of the U. S. airline companies' equipment was composed of DC-3s, but official implementation of the ICAO specifications will oust it from airline service as it cannot fulfil the new conditions.

It might be recalled, *en passant,* that the Douglas DC-3 has a sort of amphibian counterpart in the converted *Consolidated "Catalina,"* which is operated in Arctic waters, South Seas, and along South American rivers, and which carries about the same number of passengers and is equipped with the same engines as the DC-3. In its earlier rôle as a reconnaissance aircraft, it possessed an unusually long range, which was nevertheless somewhat offset by its low speed.

When the time came for developing a replacement for the DC-3, airline operators and aircraft manufacturers were all of the opinion that the new types, in order to be economical, would have to carry more passengers than that the old standard design. Thus the new aircraft designed on both sides of the Atlantic are for 30 to 40 passengers : the *Martin 2-0-2, "Convair-Liner," "Bellatrix"* and *"Ambassador,"* as well as the passenger version of a slower cargo aircraft primarily for charter operations, the *Bristol "Wayfarer."* Their predecessor was the *Curtiss-Wright CW-20,* which dates back to 1940, when it was in production as a military transport aircraft designated C-46 "Commando" ; converted for civil use, these aircraft are mostly being flown over Chinese routes.

These new types nevertheless call for somewhat longer take-off and landing runways than the DC-3 ; but despite the rigid ICAO requirements, the Americans at least, seem to be using them for serving all airports having an adequate traffic potential. It still remains to be answered whether operators are interested in an aircraft which can carry a smaller number of passengers on an economic basis, and at the same time use somewhat smaller airports than the new "big" twin-engined types. Two firms, an American one and a European one, have had the courage to attack this problem. A year ago the Douglas Aircraft Co. submitted to the U. S. airlines their *DC-9* project for 28 passengers, which would be able to take-off from and land on runways of about 4,000 ft. ; the half-hearted response on the part of operators did not justify putting it into production. And Svenska Aeroplan A. B. built the prototype of a 24- to 32-passenger transport,



Douglas DC-3 (U.S.A.)

Consolidated Vultee "Catalina" (U.S.A.)

Svenska Aeroplan SAAB 90 "Scandia" (Sweden)

Vickers Armstrongs VC.1B "Viking" (G.B.)

Ilyushin IL-12 (U.S.S.R.)

the *"Scandia."* The first contract was from A. B. Aerotransport, for ten aircraft which are to replace the airline's nineteen DC-3s. In Russia, the Li-2, a copy of the DC-3, is being replaced by the new *IL-12* for 27-32 passengers. British airline circles, at the end of the war, hurriedly had the *Vickers "Viking"* 24-seater built, with which they replaced existing or missing Douglas designs. But the economic features of this aircraft now have to be improved by increasing the seating accommodation to 27; and the new British projects for turbine-driven medium-range airliners provide for 31 to 36 passenger seats. The French have not deemed it necessary to develop a type of size between that of the 12-passenger SO-95 and that of the "Bellatrix" seating thirty passengers.

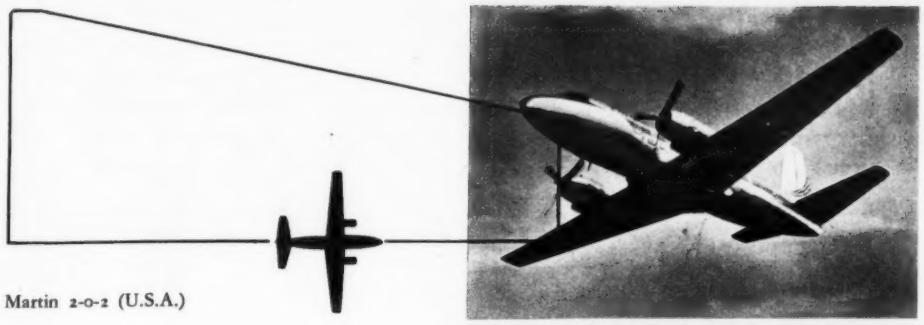
Until the ICAO specifications are finally enforced in all countries, and the remaining DC-3s banned from airline operation, it will probably not be possible to give a definite answer as to whether aircraft accommodating less than 36 passengers will disappear from

scheduled continental airline traffic. Perhaps that only then will a number of airline operators notice the presence of a gap which may require years to close.

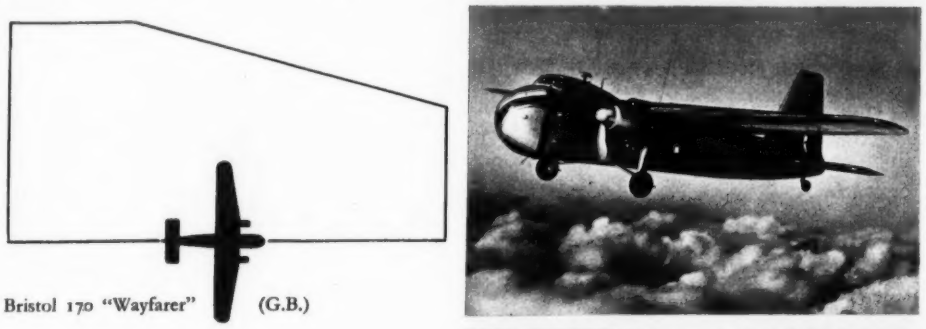
Is it necessary for twin-engined medium-range transports to have pressurisation and air-conditioning like modern trans-ocean airliners ? On the one hand we find that the Chilean LAN airline is flying daily services over the Andes (26,000 ft. altitude) with non-pressurised Martin 2-0-2's, and on the other it has been seen that British European Airways are not shunning the large extra expense of equipping their 20 "Ambassadors" with pressurised cabins, in order to be able to fly medium routes over flat country at this aircraft's most economic altitude. From this comparison, however, it should not be concluded that a fundamental controversy exists. It so happens that air-conditioning and pressurisation equipment is still expensive, heavy, and sometimes apt to give rise to unpleasant surprises. One operator may nevertheless consider it to be indispensible already today, whilst another prefers to wait a little longer. But since every type of aircraft, except really short-range feeder designs, can profit from high-altitude flight, it is not improbable that pressurisation and air-conditioning will become standard equipment for medium-range designs in a few years' time.

In the introduction to this condensed review, we were bold enough to surmise that, perhaps in two to three years' time, this article might present an objective picture of all the world's twin-engined commercial transport aircraft. Indeed, it is probable that by that time the "Scandia," "Bellatrix" and "Ambassador" — to mention only the larger types — will be in service on the European routes of their countries of origin.

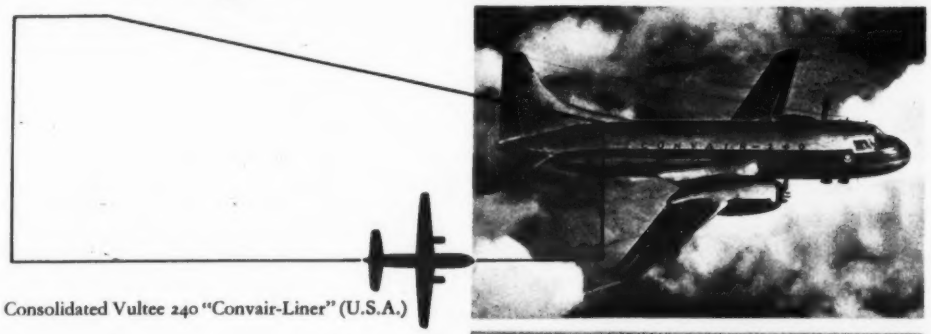
Meanwhile, we are well aware of the delays and disappointments lying between the design or announcement of a new aircraft type, and its final approval as a reliable airliner. More than once, we have seen a new design grounded for weeks during the first two years after its entering airline service. On the other hand, however, this long development period permits us to take a look around to see which twin-engined types will, say in five years' time, represent the *non plus ultra*. We can be quite straightforward about it : there are none. Is it that turbine-driven aircraft are awaited ? Or do there exist doubts about the future ? More likely the latter : the transport aircraft is finally entering that development stage in which it can be hoped to obtain more from continually improving on proven types than from magnificent new designs. *T.*



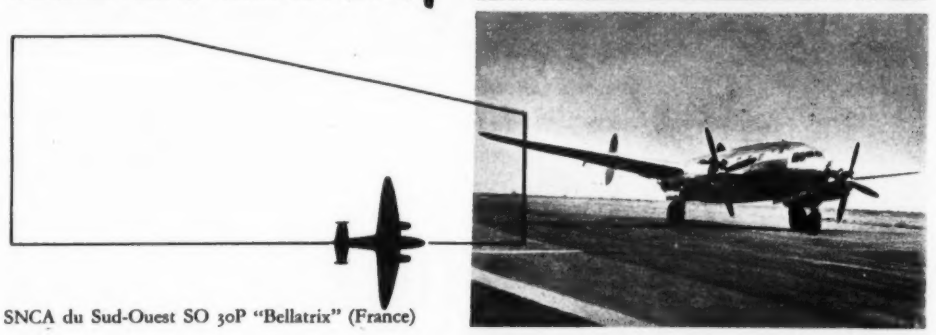
Martin 2-0-2 (U.S.A.)



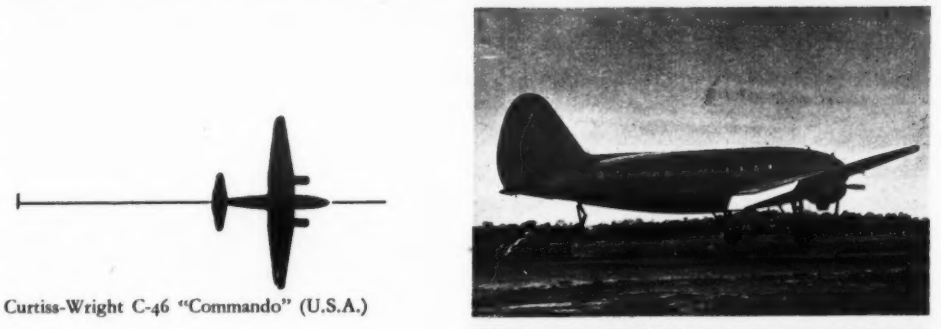
Bristol 170 "Wayfarer" (G.B.)



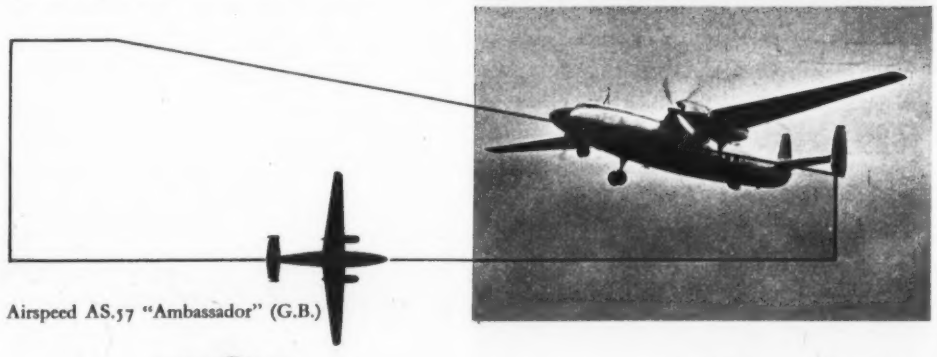
Consolidated Vultee 240 "Convair-Liner" (U.S.A.)



SNCA du Sud-Ouest SO 30P "Bellatrix" (France)



Curtiss-Wright C-46 "Commando" (U.S.A.)



Airspeed AS.57 "Ambassador" (G.B.)

The Air Hostess Told Us ...

Battle of the Bottle

The 1948 silly season, Esmeralda sighs, produced the usual crop of insanities, despite the fact that Alaskan huskies would have felt cold during most of this year's dog days. Apart from boosting Coca-Cola sales, the season transformed respectable gentlemen, whose life ambition probably was to collect meerschaums or similar objects, into crackpots or gangsters and other varieties of hoodlum.

In July one gang robbed Orly Airport, Paris, of the gold stored there, but was caught shortly after ; at the end of the same month another crowd planned a similar raid on London Airport, Heathrow, but was caught shortly before. One would-be meerschaum collector, Stephen Supina, hired a small aeroplane on July 24th and dropped a dynamite charge on United Nations headquarters at Lake Success for the purpose of "ensuring lasting peace." A little earlier a bunch of bandits tried to force a "Catalina" flying-boat of Cathay Pacific Airways down on to the sea to rob it and were so successful that they went right into the drink with it. A little later, on August 18th, an excited passenger started pumping bullets at the pilot of a Norwegian airliner and nearly produced an accident. A Frenchman was jailed in New York on a charge of importing, possessing and conspiring to import $500,000 worth of heroin into the Big City by aircraft. Then there was the case of an English air hostess trying to smuggle 84 pairs of nylons past the customs boys. On the other hand, air hostess Joan Mundy of United Air Lines had a tough time stopping passenger Phillip A. Eastman's repeated attempts to leap out of a DC-3 flying to Oakland, Calif.

Ladies not burdened with a housewife's duties also suffered from the summer. One of them, pretty Diana Cyrus, a pilot for Eagle Air Freight, Inc., of Los Angeles, was all dressed up and ready to fly around the world in a surplus D.H. "Mosquito" on August 10th. News about an actual take-off has not transpired, however. Better publicized was the start and first intermediary landing of 24-year-old ex-artist's model, Mrs. Ricarda Morrow-Tait, who took off from Cambridge, England, on August 18th. She left her husband baby-sitting with their 18-month-old offspring, presumably because the old boy couldn't fly, and engaged the services of a 25-year-old undergraduate instead. In addition to the latter, she loaded her Percival "Proctor" with such essential supplies as a lucky penny, a lucky watch, a handkerchief with the name of Lily Pons on it, two four-leaf clovers, and a lucky shilling. Neither the undergrad nor these scientific flying instruments prevented her from landing in a ditch at Marignane, Marseilles, the same night. This apparently accomplished what the cold weather had been unable to do : the ex-model and the undergrad decided to go home to mama.

Finally, there was the Battle of the Bottle. Esmeralda says she didn't witness it herself, but she got a first-hand account of it. She had a day off in New York and tried to amuse herself by going to one of the Courts. She got in just in time to hear two Puerto Ricans being charged with "committing a Federal crime on the high seas." It appeared that a DC-4 chartered from the Flying Tiger Line was on its way from Puerto Rico to New York on August 2nd when the pilot suddenly discovered that his aircraft was unaccountably tail-heavy. He handed the controls to his co-pilot and stepped into the passenger cabin. There he found most of the sixty (yes, sixty !) passengers crowded together at the far end of the DC-4, watching two men fighting tooth and nail for a bottle of rum. Somewhere underneath was the steward, Mr. Desbrow, whom the two drips had laid out cold in order to continue their brawl in peace. Captain Machado, apparently a robust person, dug out his steward, "restored a semblance of order" and turned to go back to the cockpit. One of the two gentlemen suddenly pounced on him from the rear and bit him in the ear. And so the world learned that biting a pilot in the ear in an aircraft flying over the ocean is a Federal Crime on the High Seas.

Our Favourite Air Hostess first tried to take it all easy by following the cure-all for any type of unhappiness as supplied by the sob-editor of the British magazine "Woman." "Take people as you find them," advises the sob-editor, "they are all right." Esmeralda now prefers to wait for the winter.

Battle of the Underwear

While the Puerto Ricans were fighting their battle of the bottle, the U. S. Air Force was winning its Battle of the Underwear. It proudly announced in Washington on August 2nd that as a result of its triumph its personnel will in future wear white shorts instead of the olive drab worn by the Army. "It's the bunk," said the Air Force when the Army claimed, at an early stage of the U.S.A.F.'s campaign for autonomy in pants, that khaki was needed for camouflage. Esmeralda adds, maybe all the fellows in the U.S.A.F. are so brave that the camouflage is superfluous.

Panem et circenses

You may have wondered how it came about that the Americans walked off with most of the medals dispensed at the recent Olympic Games in London. The answer is simple : bread did the trick. Convinced, apparently, that there wasn't any bread to be had in England and that Europeans were incapable of producing anything worth while anyway, President Paul H. Helms of the Helms Bakeries in Los Angeles shipped a daily load of 300 loaves of fresh bread by air six thousand miles across the American Continent and the North Atlantic, by American Airlines and American Overseas Airlines, for consumption by the U. S. athletes in England. Bread *for* the circus ! Good old vitaminized, homogenized, health-stimulating, body-building, crispy, crunchy American bread.

Esmeralda missed the Games, but she nearly got to see another show. She had all her visas and permits and signatures lined up, but at the last moment it appeared that one of her cards was the wrong colour or something. As a result, her comments on the Moscow Air Display at Tushino airport, scheduled for July 18th, are based on official announcements. Minister of Soviet Armed Forces Marshal Nikolai Bulganin, for example, stated that Russia's new multi-engined and jet-propelled aircraft were "perfect machines." Air Marshal Vershinin, C.-in-C. of the Soviet Air Force, went a little further : " . . . the Soviet Air Force is armed with new, first-rate equipment superior to foreign aeroplanes . . . There is no single aircraft, no single engine, which Comrade Stalin has failed to examine personally in design, in model and in nature" — quite a job. And "Pravda" chirped that to Soviet Russia belonged undisputed priority in the solution of all questions of aviation development.

The whole aviation parade was commanded by Major-General Vasily Stalin,who proudly declared that Papa — "wise, brilliant commander and generalissimo of the Soviet Union" — was also the best friend of Soviet aviators. That is probably why the latter were told to stay home when rains threatened on the day of the parade. They might have got wet. But they came out again a week later and flew their parade which, according to reports, was very impressive. However, Esmeralda can not understand why the Moscow Press indulged in shrieks of delight chiefly because three Polikarpov 2 aircraft succeeded in unfurling 33-foot red and blue flags in flight. "No flier in the world has hitherto tried to fly such huge flags in the air. It has now been accomplished by Soviet airmen, although it was considered technically impossible . . ." On the other hand, the strategic, tactical or commercial implications of the performance may not be obvious to everybody.

Bl.

Control Systems for Giant Aircraft

During two decades—from Lilienthal up to World War I—aeronautical pioneers of all countries experimented with the most varied types of lever arrangement before the conventional aircraft control system, as we know it today, was devised. Generations of pilots and people interested in aeronautics have since become acquainted with it : a stick or wheel for effecting pitching and rolling motions ; a rudder bar or pedals for controlling the aircraft in yaw. All attempts to deviate from this standard solution—for instance to do away with the foot control—are apt to meet with deeply-rooted mistrust.

The pilot's control elements are connected with the control surfaces by cables or rods. This transmission of motion, which was truly primitive in many early designs, has since been subjected to continuous improvement ; and the aerodynamic design of the actual control surfaces has also progressed considerably. The magnitude of the forces which have to be applied to the control elements depends on the transmission system and the design of the control surfaces. Nowadays, in perfectly controllable aircraft, these control forces increase steadily with the travel of the control surfaces, aileron, elevator and rudder forces being adjusted to one another.

In the case of small and medium-sized aircraft, and primarily of acrobatic aircraft, designers have reached a high level of perfection with control systems which give a pilot the impression that the wings are actually part of him. A flick of the control stick alters the rolling attitude and curving radius in a steep bank, a slight pressure of finger and foot enables controlled side-slipping to be accomplished, an approaching stall is discernible because the stick becomes "soft"—and even gusts are signalled back to the control column. With each particular type of aircraft, pilots soon become used to coupling specific impressions of control surface deflection and flying speed with the force they feel on the control column.

In order to cope with different aircraft loads or to compensate the loss of thrust caused by the failure of one engine, and to prevent pilots from having continually to struggle against undesirable control forces during steady cruising flight, climbing or gliding flight, designers have introduced trimming tabs. These are small auxiliary aerofoils which, located at the trailing edges of the main control surfaces, can be adjusted from the cockpit by small hand-wheels or levers, thereby displacing the neutral position of the main surfaces. A further and very decisive alleviation of the pilot's task—in the case of medium and large aircraft—has been brought about by automatic piloting devices ; early systems could only keep aircraft on course, but they have now been developed to a point where they can control the aircraft in all three directions. They involve electric or electro-hydraulic power systems which move the control surfaces for the pilot ; to do so they receive impulses through gyroscopic devices which, in turn, control the servo motors of the control surfaces.

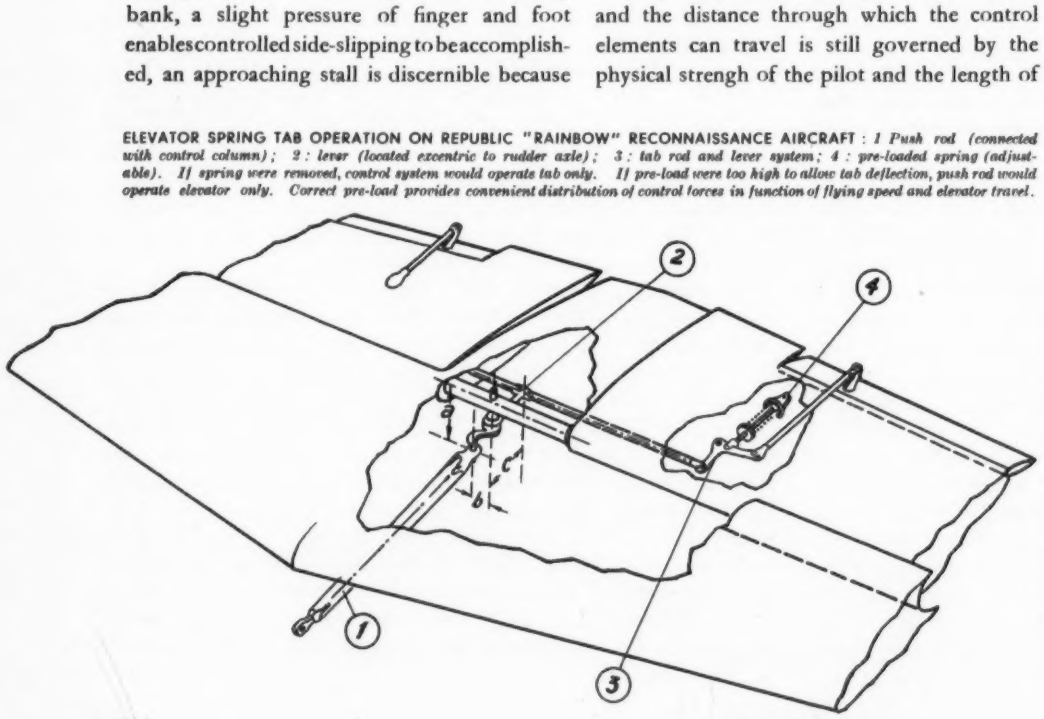
With the rapid increases in size and speed of aircraft during recent years, the construction of control systems has become more and more difficult, mostly calling for considerable developmental costs. Whereas stick forces and the distance through which the control elements can travel is still governed by the physical strengh of the pilot and the length of his arms and legs, the forces acting on the control surfaces increase proportionally to the area of the surfaces and the square of the flying speed. At the same time, the requirement that even large surface deflections must be attainable with relatively small stick and pedal travel, must remain for reasons of flying safety.

The various methods with which designers first began coping with these increasing forces on the control surfaces, come under the heading of "aerodynamic balance," which involves the displacement of the surface's axis of rotation towards the centre of pressure of the control surface. The C.P., however, does not maintain its position as the control surface is deflected, but wanders forwards and backwards. The larger the control surfaces became, the more exactly the aerodynamic balance had to be achieved. A fraction of an inch was decisive, for an often only slight downstream position of the C.P. relative to the axis of rotation incurred excessive control forces, and conversely, an upstream position led to dangerous over-balance, *i.e.,* reversal of the control force. More often than not, tedious flight tests and countless modifications were necessary before a control system could finally be adopted.

Whereas tabs attached to the trailing edges of the main control surfaces were first used for achieving aerodynamic balance (whereby they always deflect in opposite directions to the control surface), they were later connected directly with the control elements of a number of large aircraft, including the Convair B-36 (or XC-99) and Republic "Rainbow." This direct operation of the large control surfaces is known as spring tab control. It seems to represent the last possible means by which aircraft can be controlled directly through the physical efforts of the pilot.

An example of an ingenious system of spring tab operation is given in the accompanying sketch of the elevator control system of the "Rainbow" (Republic XF-12).[1] The combination of the spring tab operation and aerodynamic balance is very interesting : delicate response is received during small elevator deflections, and very noticeable alleviation, increasing constantly, attends large deflections and high flying speeds. This is accomplished by a spring (4) with a pre-load system. Without the spring, the tabs would be operated directly by the pilot's physical force, but when pre-loaded, the tab will not deflect until a given control stick force is exceeded. Hence for small deflections, as long as the stick force

ELEVATOR SPRING TAB OPERATION ON REPUBLIC "RAINBOW" RECONNAISSANCE AIRCRAFT : *1 Push rod (connected with control column) ; 2 : lever (located excentric to rudder axle) ; 3 : tab rod and lever system ; 4 : pre-loaded spring (adjustable). If spring were removed, control system would operate tab only. If pre-load were too high to allow tab deflection, push rod would operate elevator only. Correct pre-load provides convenient distribution of control forces in function of flying speed and elevator travel.*

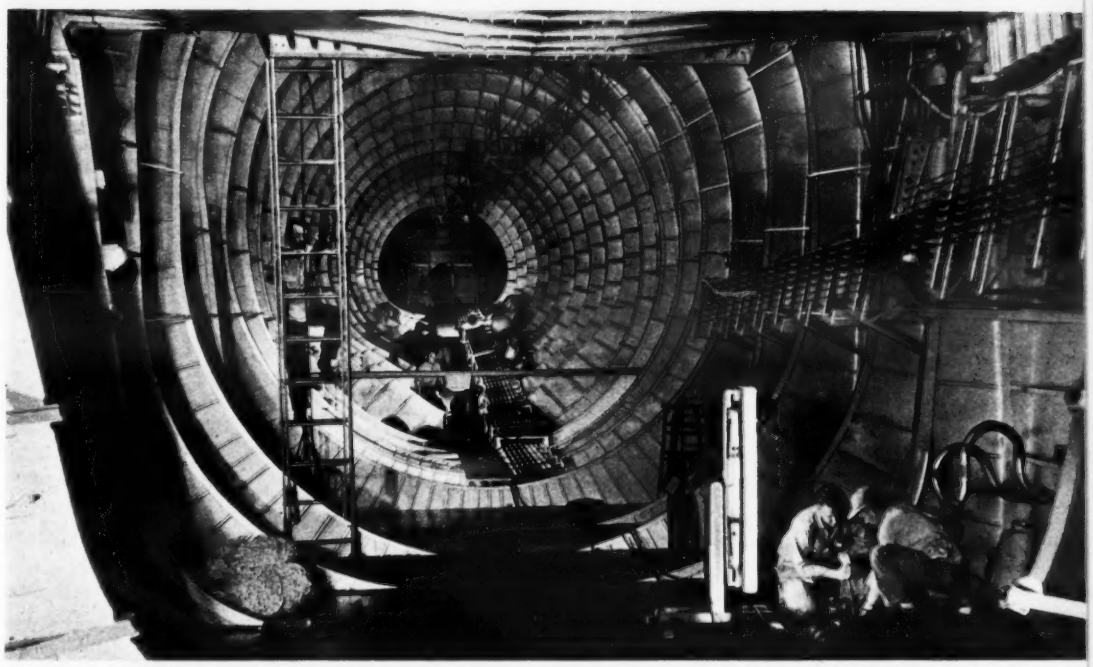


[1] Cf. "Interavia, Review of World Aviation," No. 7. Vol. I, pp. 45-51.

remains smaller than that exercised by the pre-load, the elevator is moved directly (lever *a*). If the spring begins to give, then the tab deflects and takes over the entire operation. In the case of very small pre-loads, the elevator is operated entirely by the aerodynamic forces on the tabs ; if the pre-load is too high (compared to the stick force), the elevator is moved directly by the pilot. All three control surfaces of the "Rainbow" are equipped with spring tabs operating in a similar way.

Another means of alleviating the pilot's task is offered by hydraulic power boosters, which are used in a number of large commercial airliners—for instance in the Lockheed "Constellation" for all control surfaces, and in the Boeing "Stratocruiser" for the rudder. These power systems are designed in such a manner that the pilot has to supply a definitive percentage of control hinge moment in order to preserve the "feel" of the control. In the event of a breakdown in the power source, or in any other emergency, the pilot can cut out the system and take over full control. This calls for considerably more effort on his part, of course, but he can still continue his flight ; the effect of the trimming tabs may then offer a certain degree of alleviation.

In the case of still larger aircraft, it is neither possible for the controls to be operated directly, nor for the pilot's muscular force to take over in the event of a breakdown in a booster system such as that described above. The 180-ton "Hercules" flying-boat of Howard Hughes,[2] which features a span of some 320 feet, is consequently fitted with a hydraulic telecontrol system. In the place of control rods, hydraulic conduits lead to the control surfaces. Meanwhile, long pipes for carrying high-pressure hydraulic fluid all the same present considerable constructional difficulties : thermal expansion of the tubes and deformations of the hull and wing have to be taken into account ; the numerous joints have to be extremely well sealed. The slightest leakage, or a breakdown in the power source, could have catastrophic consequences. For safety reasons, therefore, Hughes decided to install two completely independent, self-contained and individually sufficient telecontrol systems. The flight controls in the cockpit are conventionally designed, and arranged so that an adjustable fraction of the air forces on the control surface is signalled back to the pilot through the hydraulic system. The correct relationship between the position of the pilot's controls and that of the control surfaces is maintained by wire cables. In this way, the pilot directly feels surface deflections and stick forces ; even gusts are transmitted back through the hydraulic system and are "feelable" on the control elements. Since Hughes has so far confined himself to a number of taxiing trials and a short but successful first flight, there are as yet no adequate data on the service reliability of his control system.



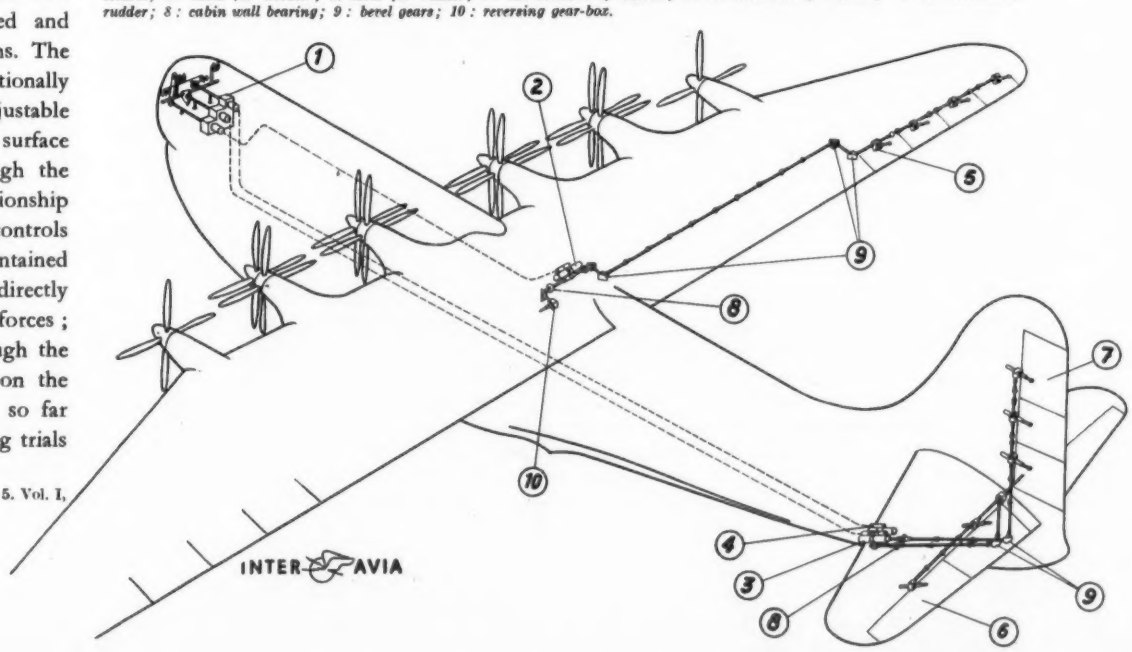
THE 180-TON "HERCULES" FLYING-BOAT *(eight "Wasp Majors" of 3,500 H. P.) has a system of hydraulic telecontrol. Rods are replaced by hydraulic conduits leading to control surfaces. Cables further provide a suitable ratio between travel of cockpit levers and that of control surfaces.*

MODEL OF ONE OF THE THREE POWER UNITS, *designed and developed by Boulton Paul Aircraft, Ltd. Each unit comprises two identical and independent torque converters. From left to right, to centre : D. C. motors, hydraulic generators, hydraulic motors, differential gear-box ; to the fore is the mechanically-driven shaft for controlling hydraulic generators, and two telecontrol devices which are coupled with the pilot's controls.*

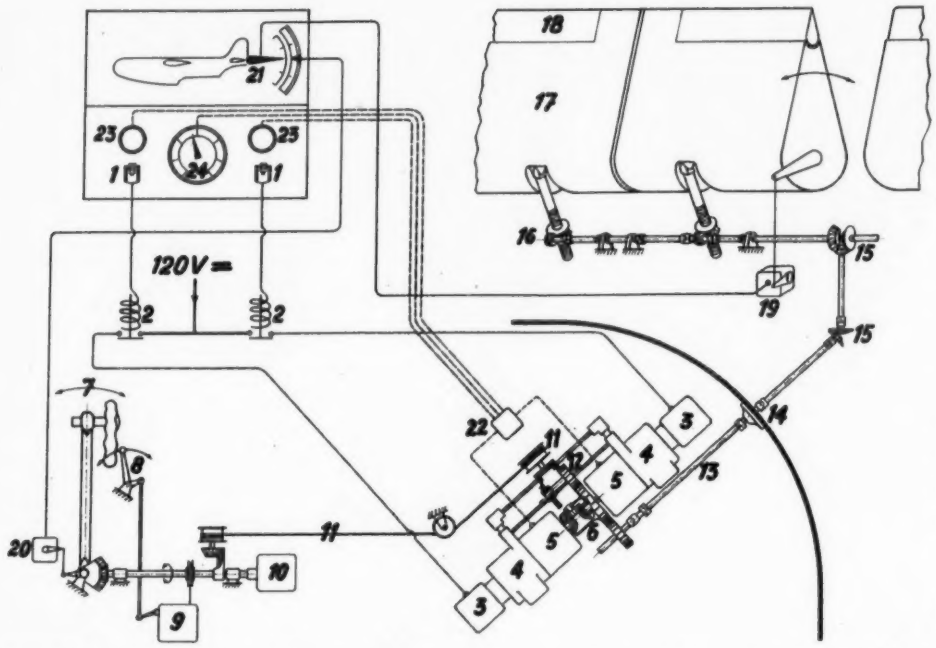
Saunders-Roe Ltd., the British firm of aircraft constructors, have gone another step forward by designing and developing, in conjunction with Boulton Paul Aircraft Ltd., an electro-hydraulic control system for their 140-ton SR 45 flying-boat. Here, too, the orthodox control elements have been retained, but there is no direct transmission of forces between these and the control surfaces. The cockpit elements are more or less relegated to "push-button" devices, and the circuit of the forces runs solely between the power sources and the control surfaces.

The designers of this system have made provisions for all sensitive organs to be accessible during flight, and for these to be duplicated in the interest of safety. The power units—each comprises two identical electro-hydraulic torque converters—for rudder, elevator and aileron control are therefore placed as near as possible to the control surfaces, but are all the same situated accessibly within the pressurised portion of the hull. If one of the

THE 140-TON SARO SR/45 *flying-boat is to have ten 3,500-S. H. P. Bristol "Proteus" propeller-turbines and a two-deck pressurised hull for 100 passengers. Control surfaces are operated by an electro-hydraulic servo system with three power units located inside the pressurised hull. 1 : Cockpit control elements, auto-pilot servos and feel generators ; 2 : power unit and torque shafts for aileron control ; 3 : same for elevator ; 4. same for rudder ; 5 : sub-division of aileron ; 6 : sub-division of elevator ; 7 : sub-division of rudder ; 8 : cabin wall bearing ; 9 : bevel gears ; 10 : reversing gear-box.*



[2] Cf. "Interavia, Review of World Aviation," No. 5. Vol. I, pp. 26-33.



ELEVATOR CONTROL SYSTEM : *1 : Off and on switches ; 2 : electromagnetic contacts ; 3 : electric motors ; 4 : hydraulic generators ; 5 : hydraulic motors ; 6 : differential gear-box ; 7 : control column ; 8 : elevator trimmer ; 9 : feel generator ; 10 : auto-pilot servo ; 11 : transmission of control column movements ; 12 : follow-up gear ; 13 : torque shaft ; 14 : pressure cabin wall bearing ; 15 : bevel gears ; 16 : worm and wheel reduction, and screw jack ; 17 : elevator sub-division ; 18 : aerodynamic balance (geared tab) ; 19 and 20 : desynn transmitters ; 21 : follow-up desynn pointers ; 22 : differential measuring devices ; 23 : warning lights ; 24 : loss of power indicator.*

converters breaks down, the other one automatically takes over the entire control surface operation ; moreover, damaged parts can be repaired or replaced in flight, since all the main elements of the control system are interchangeable.

A model of one of the three identical electro-hydraulic torque converters, designed and developed by Boulton Paul Aircraft Ltd. for the SR 45, is shown in an accompanying sketch. Despite their compact configuration, their length is considerable, amounting to about six feet. At the outer ends are 120-volt D.C. motors which, fed by the aircraft's electrical system, rotate continuously (that is to say during flight and taxi operations) at the same r.p.m. (4,000) but yielding different outputs. Together they drive, each via a hydraulic unit with an infinitely variable speed, one of the torque shafts. The gear-box, from which this shaft branches out, is located in the centre and is very similar to the differential gear-box in a car's rear axle (one can imagine the torque converters in the place of the wheels and the control surface in the place of the main drive shaft). If one of the torque converters of a power unit fails, the other maintains the full output torque, but reduces the maximum total output speed by 50 per cent. Control response will consequently be somewhat slower, but the aircraft will remain completely controllable.

Since the electric motors always turn at the same r.p.m. and in the same direction, the hydraulic unit must not only be variable but also reversible. Their pumping side therefore works with differentiating fluid delivery and delivery direction, whereas the motor side features a fixed capacity, and adjusts r.p.m. and direction in accordance with the amount of fluid being received.

Every movement of a control element in the cockpit (column, wheel or pedal) incurs, through simple cables or electric telecontrol, a corresponding feed of fluid into the hydraulic motor, resulting in a specific movement of the torque shaft and control surface jack. With this alone, however, merely the velocity of deflection of the control surfaces could be regulated, and there would be no control of the actual angle of deflection. It was therefore necessary to create an adjustment system which continuously balanced the actual deflections of the control surfaces with those of the control elements in the cockpit, using the differences as impulses for the power unit. If the angular difference is, or becomes, zero—*i.e.* if the specific control surface is in the desired position—there may be no rotation of the main torque shaft ; conversely, the greater the difference, the greater must be the velocity of adjustment. As can be seen from the diagram of the elevator control system, the two slender follow-up shafts running to the hydraulic system serve this purpose. The one is rotated by the deflection of the control column via cable drums and bevel gears ; the other, in accordance with the control surface deflection, via layshafts direct by the main torque shaft. The combined action of both shafts on each hydraulic system regulates r.p.m. and direction of rotation of the hydraulic motor. In the case of electric telecontrol (model), one of the regulating shafts is replaced by electric motors. In order that the pilot may observe, at least indirectly, the behaviour of his control system, an overall picture of control position and accuracy of follow-up is given by two concentric desynn pointers : one indicating pilot's control and the other indicating the position of the corresponding control surface. Warning lights and indicators are also incorporated on the instrument panel, giving evidence of power unit failure or deterioration.

The torque shaft from each power unit drives, via a wheel and worm reduction, a series of screw jacks, thus operating sub-divisions of each control surface. The driving shaft is connected in series with the worm shaft, through universal joints, but the worm itself is held on to the shaft by shear keys, set to shear at 100 per cent. maximum overload. Thus if a jack should seize, through some unforseeable cause, and sufficient torque is applied to the driving shaft, the shear keys will fail, thus freeing the jack and allowing the torque shaft to continue operating. For this reason, the control surfaces of the aircraft have been split up into sub-divisions—one per jack—so enabling this scheme to be carried out.

An electro-hydraulic control system of this sort could, in theory, function without the least physical effort on the part of the pilot, and be operated, for instance, by small hand-wheels or push buttons. For psychological reasons, however, the designers have avoided going to such extremities, and have preferred to provide the pilot with impressions similar to those given him by any other aircraft. For this reason, there is a synthetic "feel" generator, which causes stick forces to arise artificially and can be adjusted in accordance with flying speed and control surface travel. Basically, it is either a hydraulic ram or a spring connected directly to each of the pilot's controls. Provision is made for varying the centralising force, this being proportional to the flying speed. Finally, the servo equipment of the three-axial auto-pilot control is coupled to the pilot's control elements and not, as is usually the case, to the control surfaces.

Besides being subjected to test bench trials, the Saro control system will also undergo 1,000 flight hours on a "Sunderland" flying-boat. A velocity of deflection of 24 deg./sec. has been attained in ground trials, and it is expected that 45 deg./sec. will be reached during the "Sunderland" flight trials. A velocity of 30 deg./sec. is envisaged for the SR 45.

It is right that one should display a keen interest in the results of the flight tests ; for this represents the first control system which gives the pilot no direct feel of control surface movement and forces, but provides him with synthetic impressions through the medium of the feel generator. If gusts act on the control surfaces, or if the latter become damaged through some reason or other, then the pilot does not feel this directly. On the other hand, the Saro system eliminates the necessity of long hydraulic conduits and their attendant possibilities of failure.

It may be mentioned further that the manufacturers anticipate a large saving in weight, as compared with a direct system of control. The Saro system can be built much lighter than other systems because it consists largely of control cables or else electric wires. Apart from this, there is no necessity for mass-balance weights for the control surfaces, since the irreversibility of the screwjacks endows the control surface sub-divisions with such a high degree of stiffness that there is no danger of wing or tailplane flutter. Saro engineers anticipate a weight saving of about 1,300 lbs.

As soon as adequate operational data are available—primarily as regards manoeuvrability of the control system and sensitivity of the power units to damage—it will be possible to obtain further simplifications and savings in weight. This could be done by improving on the aerodynamic balance of the control surfaces and placing the consequently smaller power units nearer to the surfaces.

The Saro power-operated control system represents the completion of a developmental period which can be traced back to the earliest days of aeronautics. Meanwhile, it will not be final—there are no final solutions in aeronautics—but it nevertheless represents a new idea which has never before been realised. It also denotes the latest development stage in the widening of the relation between pilot and aircraft. The next step will indeed have to be a "wireless" system of control surface operation. *Ri.*

Saxo

I first met Saxo at the Q. B. G.

Despite its mysterious turn, this sentence happens to make perfect sense.

The Q.B.G. is a club and Saxo is an aircraft mechanic.

The Q.B.G. was founded in Paris about a year ago, by a number of airline pilots who wanted to get together now and again for a spot of hangar flying.

You'll admit that it's rather difficult to hold such conversations during working hours. It is obvious that if a "Paris—Buenos-Aires" wants to chat with a "New York—Paris," he has a much better opportunity of doing so at the Q.B.G. than when they meet each other in mid-air. Anyway, if they do manage to meet, they only just have time to say "hello." On the other hand, of course, it's really better if they don't meet at all.

For this reason a group of French pilots concocted the idea of forming a club of their own, which, however, is also open to all their foreign buddies.

They were given an "H.Q." in a building where there are several airline offices. But they were in for quite a surprise when they asked exactly where their "H.Q." was ; for they were shown a flight of steps leading down into a black void.

"Down in the cellar," was the abrupt reply.

Being made of different stuff than ordinary mortals, the pilots actually found this a really excellent idea. You see, they spend so many long hours above the ground that they found it perfectly normal to go underground from time to time. In that way, one thing more or less balanced the other.

As for the club's name, Q.B.G., unless I'm mistaken (and if I'm mistaken you'll forgive me for being a greenhorn) means "you may land." In the present case, of course, it could be interpreted as meaning "you can bury yourself in the ground," so we can only hope that pilots coming in to Paris won't be too eager.

Meanwhile, yours truly landed the other day at the Q.B.G.

The friend who was navigating me to the club told me that, several months previously, the "H.Q." was pitch black, cluttered with planks, fallen plaster, cobwebs, old boxes, delapidated furniture and moth-eaten bits of material. It's almost unbelievable ; for it is now a fine, spacious room, with walls tastefully and gaily painted in cream, blue and green.

On one side there are comfortable armchairs, between tables littered with magazines, whilst the other side is given up to the important business of eating. The tables were laid invitingly, and there was nothing more for us to do but sit down and order.

But my friend took me by the arm and, making me roll sharply to port, appropriately parked me in front of a superb bar, where hundreds of bottles promised that it wouldn't be long before I was fully initiated into the secrets of refuelling in flight.

A restful light, softened by ingenious reflectors, makes the bottles wink enticingly. The barman gave my friend a knowing look. "What will it be, sir ? Lemon squash, or the usual 100 octane ?"

The lemon squash is for pilots who have to take off within the next twenty-four hours. The 100 octane is just about enough to put a novice to sleep for twenty-four hours.

Just as my eyeballs had bounced back into their sockets from the opposite wall, my friend suddenly shouted out to another member going up the stairs.

"Heh ! Saxo ! Come over here, you son of a gun !"

But Saxo was apparently in a hurry, for he quickly excused himself from joining us. My friend turned around towards me again.

"Is Saxo really his name ?" I asked.

"Of course not. It's his nickname, but he never gets called by anything else."

He went on to explain. "In 1943 I was in the Lybian desert, piloting an ambulance plane. A foul crate. Saxo was my mechanic. Everybody calls him Saxo because he's a saxophone fan. It seemed fated that every time we wanted a bit of a rest, he would start blowing his wretched saxophone to 'soothe' us.

We were just about to take off one day. I was already in the cockpit when I saw Saxo coming with his inseparable instrument in a case.

"You're nuts," I told him.

"That's a matter of opinion."

"Have you checked the engines ?"

"Of course. I spent two hours on them."

"Everything O.K. ?"

"Quite O.K."

We took off and started to climb. Hardly a minute later, a tune which was anything but captivating rose above the noise of the engine. Needless to say, it was the saxophone.

I scribbled a note and passed it to my companion. "Are you trying to break my eardrums just for the sake of passing the time ?"

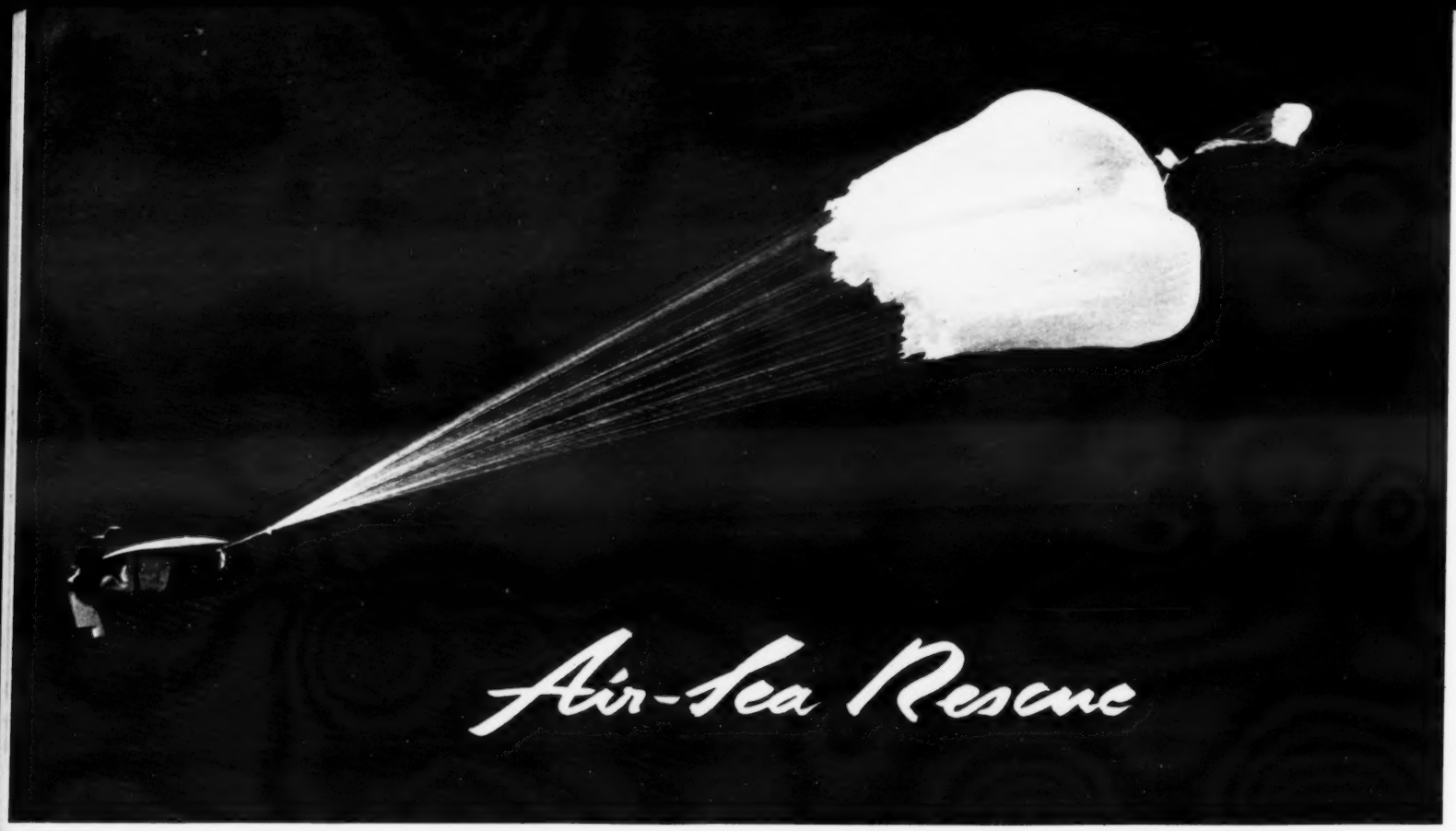
He stopped playing just long enough to write an answer. "Not at all. I'm playing so as not to hear the queer noise the engines are making."

I hardly need to tell you that I had goose pimples all up my spine. It was with a huge sigh of relief that I landed the plane, two hours later, at its destination in mid desert."

"Did you say anything to Saxo about his particularly original way of using his instrument to good purpose ?" I wanted to know.

"What was the good ? He still kept on playing, so that mine would just have been a second voice crying in the wilderness !"

Yves Grosrichard.

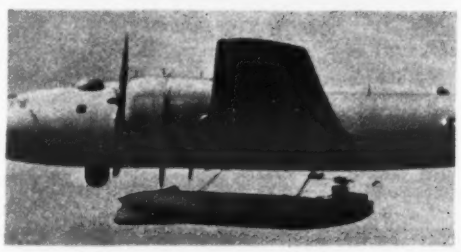


Air-Sea Rescue

Despite all precautionary measures and preparations to increase the safety in modern airline operations, it has happened that aircraft have disappeared with all hands on board during long trans-Atlantic flights. It is not always possible to find the exact location of the accident — in some cases no radio messages are received to signal a crash or a state of emergency — so that only the last position report can be used to surmise where the crash took place. Moreover, it has been seen that such accidents over the high seas frequently occur suddenly, and only exceptionally allow the crew sufficient time to give precise details over the radio.

True, complete losses of airliners over oceans occur very seldom, if one takes into comparison the number of miles flown daily over the entire globe. Besides this, every passenger knows that all preparations have been made on board his aircraft in order to save every human life in the case of a forced landing. In addition to the life-saving jackets which lie ready next to each seat, there are also several large rubber dinghies, equipped with every imaginable item in the way of radio equipment, food, signalling devices, and so forth. And despite all this, it happens in some cases that these aids are not sufficient.

Let us take the favourable case of a forced landing on water, in which all passengers and crew members manage to leave the aircraft unhurt and take to their rubber dinghies at some spot many hundred miles from any inhabited area. Everything has been fine up to the present, but to save them from this last dilemma it is imperative that the air-sea rescue service intervenes. We all know that the International Civil Aviation Organisation maintains a good number of well-equipped rescue ships, which stand by in readiness at precisely located positions along the most-flown Atlantic coasts. If, however, the pilot is not able to effect his emergency landing in the vicinity of one of these ships, then it can happen that the survivors be exposed to the elements for many long hours — perhaps even for days. Apart from the fact that Atlantic airline passengers mostly include a good number of women and children, it must always be taken into account that minor injuries can easily result during a forced landing. This amplifies all the more the urgency of quickest possible rescue service.



The rescue equipment carried in modern long-range airliners flying scheduled trans-Atlantic services was developed by the American Air Force during the last war. And today it is again the armed services which have gone another step forward, and recently carried out initial tests with a new type of rescue equipment which, carried by aircraft of the air-sea rescue service, can be dropped

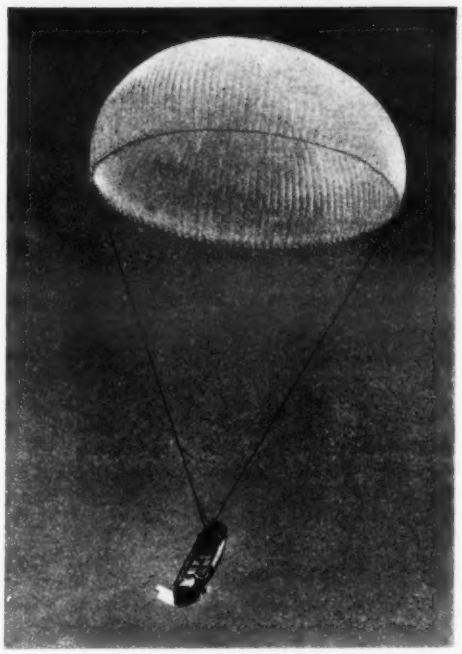
THE "EDO A-3" AIRBORNE LIFEBOAT is designed to fit snugly against a B-29 fuselage and is carried with its stern facing forward. For dropping, the boat is swung out in horizontal position and the small auxiliary parachute simultaneously thrown out. The cowling at the left (stern) end of the boat encloses the rudder and propeller.

so as to fall in the immediate vicinity of the survivors of a crash.

The new *A-3 airborne lifeboat* of the U.S. Air Force is carried beneath the fuselage of a Boeing B-29 four-engined bomber and can be dropped by parachute. The design of this boat was guided by the demands for maximum seaworthiness, complete equipment with navigational instruments, means of propulsion for long distances, and construction methods approaching as closely as possible those of aircraft construction so as to facilitate maintenance and repair by aircraft personnel. The construction of the A-3 airborne lifeboat was entrusted to the *Edo Corporation,* of College Point, N. Y., a firm which has hitherto manufactured the greater part of all aircraft floats in the U.S.A., and towards the end of the war developed a single-float scout-observation plane, the Edo XOSE-1, for the U.S. Navy.

Overall length of the A-3 lifeboat is 29 feet 9 inches ; it is constructed of aluminium alloy throughout and features twenty watertight departments above a keelson which is continuous from the bow to the forward end of the engine compartment. The numerous items of equipment (an inboard engine endows it with a range of 500 miles) are all housed in hermetically-sealed containers positioned in the sides of the hull. Whereas earlier experimental airborne lifeboats required three or more parachutes, the A-3 can be dropped by one single nylon parachute which measures 100 feet in diameter and contains a total of 7,857 square feet of material. The distance from the top of the open parachute to the lower end of the boat is 150 feet, and a safe dropping can be made from a minimum altitude of about 800 feet.

For attaching the boat, which externally reminds one of the "Speedpak" cargo container developed by Lockheed's for their "Constellation," a launching gear had to be built which threw the boat clear of the B-29 and also dropped it in a correct position. This consists of displacing arms of welded tubing in V-shaped arrangement, which, when released, swing downwards and backwards, releasing the boat once they have reached a vertical position. The main parachute is opened by a small auxiliary parachute and is coupled at two points with the boat in such a way that the latter's bow, which is equipped with two stabilising fins, hits the water first. The boat, which travels stern forwards when attached to the aircraft, assumes an angle of about 50 degrees to the horizontal whilst in the air ; in this way any damage during the impact with the water is precluded. Furthermore, pliable containers of rubberised fabric, located at both ends of the boat, are inflated automatically with CO_2 whilst the boat is dropping, thus ensuring that the boat will right itself even if there are heavy waves.



THE BIG PARACHUTE measures 100 feet across and 7,857 square feet of nylon went into its making.

A protective cowling of aluminium alloy covers the propeller and rudder of the lifeboat, so that none of these parts can foul the parachute cords during the jettisoning. As soon as the containers housing the instruments for navigation and engine servicing are opened in the boat, this cowling is automatically jettisoned.

Since there is a possibility that the people using this boat may never before in their lives have had to deal with anything similar, its operation has been simplified to such a degree, and so many details and instructions have been provided, that even the worst novice cannot make a mistake with the best will in the world.

To list all the items of equipment in the boat, which are all based on experience gained by the Allied air forces during the war, would be far beyond the scope of this article. But really everything has been thought of. A grab line extends along each side of the boat. Any person swimming up to the boat will instinctively pull on this line, and thereby automatically actuate a door-release mechanism. There is a spring-loaded plunger that pushes the door outward, causing a ladder to unfold and drop to boarding position. Moreover, a demountable metal framework can be erected over the centre cockpit and covered by a nylon canopy to provide shelter from inclement weather. Large-size water-tight hatches contain a supply of warm clothes for fifteen men, as well as food and other provisions. In addition to heating equipment and many other items, there is also a salt water converter which supplies fresh water when the engine is running.

For handling on the ground, the A-3 airborne lifeboat has a three-point beaching gear which enable the boat to be towed at speeds up to 40 m.p.h. and incorporates screw jacks for raising it into mounting position under a B-29.

The Edo Corporation, now that the tests have been successfully completed and a quantity production contract has been awarded, are temporarily working for the Air Force alone. Meanwhile, however, the operation of large numbers of these boats by military air-sea rescue service stations will simultaneously mean a major advance towards increasing the safety in international civil aviation.

PLIABLE, SELF-RIGHTING CHAMBERS are attached at either end of the boat. Automatically inflated during the dropping, they ensure against capsizing, even in a heavy sea. The two stabilising fins are detached and discarded after hitting the water. The folded nylon parachute lies in the bow of the boat ; the small auxiliary parachute is visible at the extreme bow. Complete with all equipment, the A-3 airborne lifeboat weighs nearly two tons.

Official Bulletin of the

FÉDÉRATION AÉRONAUTIQUE INTERNATIONALE, PARIS

F.A.I.

In response to the invitation of the Aero Club of France, the F.A.I. held its 41st General Conference in Paris, from September 27th to October 1st.

During the course of this meeting a great number of questions relative to the International Sporting Code and its application, to private flying, gliding, scale models and ballooning, were listed on the agenda. All these proposals had previously been examined by the Commission. The most important are mentioned below.

International Commission of Aeronautical Sport.

Modification of the regulations concerning records.
New categories for sailplane records, proposed by the Gliding Commission.
Control of records by means of barographs ; the influence of high speeds on the working of such apparatus. The necessity of employing other means of control.
The presence of observers on board aircraft during record attempts.
Submission of the revised Sporting Code.
Recent ICAO measures which are of interest to the Sporting Commission, notably relative to pilots' licences and the standardisation of measuring units. Conditions for the first competition for the Prince Georges Bibesco Trophy.

International Commission of Aerial Touring.

Customs exemption for the fuel used by private aircraft.
International recognition of national certificates of airworthiness.
International recognition of national private pilots' certificates.
Regulations for rotary-wing aircraft.
Renewal of the aerial touring card, giving the right of exemption from landing and take-off fees.
The establishment of a touring office by each aero club.
The necessity to equip private aircraft with transmitting and receiving sets weighing less than 20 kilograms.

International Commission for Models.

Varied modifications with regard to the regulations governing model aircraft.
The creation of a category for high-speed, jet-propelled models.
Introduction of classifications and rules for the categories of baby models and models for circular flight.

Commission for Aerostation

Draft regulations for the Gordon-Bennett Trophy race for balloons, to take place in 1949.
Simplified method for handicapping balloons of different volume and weight.
Examination of ICAO decisions regarding the licencing of balloon pilots.

International Gliding Commission.

The agenda of this commission, which met at Samedan, Switzerland, from July 27th to 28th, was published in the September issue of Interavia.

At the same time the first meeting of the International Scientific and Technical Organisation on Gliding (OSTIV : Organisme Scientifique et Technique de Vol à Voile), succeeding the ISTUS, was held from July 28th to 31st, also at Samedan, under the presidency of Mr. Jarland, representing the Aero Club of France.

It was decided that this organisation shall function provisionally as a sub-committee of the F.A.I. Gliding Commission, and that its definite status shall be the object of a later decision.

Two sections were formed, the first being more especially concerned with questions regarding the operation of sailplanes, the second concerning scientific and technical research. A working programme was drafted, which will be drawn up in final form on the occasion of the next meeting, scheduled to take place in Paris next year.

The OSTIV has established its headquarters in Paris (6, rue Galilée), and a temporary committee for preparing the next meeting includes the following members :

President : Mr. Jarlaud (France).
Vice-Presidents :
Dr. Eichenberger (Switzerland)
Mr. A. de Lange (Holland).
Secretary-Treasurer :
Mr. A. Cartier (France).

The above decisions were submitted to the General Conference of the F.A.I.

A detailed account of the results of the 41st General Conference of the F.A.I. will be given in next month's issue of "Interavia Review."

Book Reviews

Femmes de l'Air, by Roland Tessier. — Flammarion, Paris, 1948.

Adrienne Bolland, Lena Bernstein, Maryse Bastier, Maryse Hilsz, Hélène Boucher, Amy Johnson, Amelia Earhardt, Jean Batten . . . names which helped to make aeronautical history. But their's was a day when aviation was still a sport for heroes . . . and heroines !

Mr. Tessier retraces the careers of the most famous women pilots, beginning with the ascent made by four reputedly beautiful ladies — the Marquise and the Comtesse de Montalembert, the Comtesse de Podenas, and Mademoiselle de Lagarde — in the balloon of Pilâtre de Roziers in 1784. The author has a wealth of documentation at his disposal, and his style is captivating.

Unfortunately, the great exploits of yesterday appear as banalities today. As the famed women pilot, Regina Winzca, puts it : "A woman wishing to become a pilot must be very healthy and . . . very wealthy." (French.) *J.*

Airline Traffic and Operations, by Morris B. Baker. — McGraw-Hill Book Company, Inc., New York and London, 1947.

In this book, Mr. Baker has outlined the wide field of knowledge he has acquired as an industrial engineer with Trans World Airline. His intention has not been to write a mere reference book for airline employees, but to present an overall picture of the manifold tasks involved in airline traffic and operations.

The number of subjects treated is astonishing. Beginning with the elements of an airline company's sales organisation, the book goes on to describe the activities of ticketing organisations, central sales organisations, the seat reservation system, up to the correct way to fill out the many forms and certificates. Every phase of the airline business is mentioned, and even the young lady who entertains dreams of one day becoming an air hostess, will learn that this profession entails more than wearing a smart uniform.

Although Mr. Baker confines his account to the U. S. airline industry, non-Americans will also be able to profit from his clear picture of the complex structure of an airline company and its methods of co-ordinating the work of all departments and divisions. *Ba.*

Vingt-cinq Années d'Aviation Militaire, by J. Hébrard, général de brigade aérienne. — Edition Albin Michel, Paris.

The first volume of this work was devoted to the period preceding the collapse of the French Air Force (cf. "Interavia Review," No. 4, Vol. II). The present book describes its activities during World War II. It is understandable that so many French military authors are taking on the thankless task of completely clarifying the reasons underlying that sad collapse. But their findings are of interest not only to the French. The phrase written by Paul Valéry and cited by the author, applies to all of us : "It is dangerous to wander through life looking backwards." (French.) *He.*

THE MONTH IN REVIEW

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AVIATION POLITICS

● Reciprocal exclusion of Western and Eastern air attachés from air displays is reported from Moscow and Washington. The U.S. measure is explained as resulting from a policy under which foreign personnel are only invited to U.S. military bases provided that reciprocal invitations are given U.S. military representatives abroad; the annual Soviet Air Show is usually the only type of military or technical aeronautical event which the U.S. air attaché in Moscow is permitted to attend.

● Record peace-time estimates for the Royal Canadian Air Force have been approved for 1948-49 by Parliament. The total is $136,008,508, an increase of more than 50 per cent. over the previous year.

● A bilateral civil aviation agreement between Switzerland and Brazil was concluded in Berne on August 10th.

● A bilateral air agreement between France and Spain, running for an unlimited period, was concluded at La Goja on July 29th.

FIRST FLIGHTS

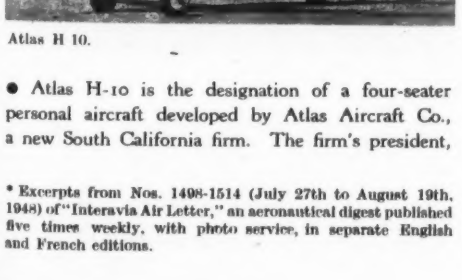
● The prototype of the North American XAJ-1 carrier-borne bomber recently made its first flight. Power plant consists of two piston engines in wing nacelles and one turbo-jet unit housed in the fuselage.

● The second prototype of the Boeing XB-47 "Stratojet" six-jet bomber made its first flight on July 21st, with test pilots Robert M. Robbins and Scott Osler at the controls. The flight was from the Boeing factory airfield at Seattle, Wash., to the Air Force base, Moses Lake Field, Wash.

● The Nord 1221 recently made its first flight from the Mureaux flight test centre in France. Developed from the Nord 1200 "Norécrin" three-seater personal aircraft, it is intended for use as a two- to three-seater fighter trainer. Power is supplied by a Mathis air-cooled engine of 195 H.P.

NEW AIRCRAFT

● Boeing B-54 is the designation of the Boeing B-50C bomber powered by Pratt & Whitney R-4360 VDT "Wasp Major" air-cooled 28-cylinder four-row radials. The installation of these engines called for such large-scale modification that it was decided to redesignate the aircraft.



Atlas H 10.

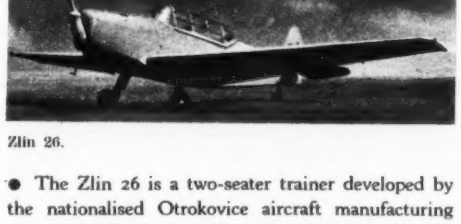
● Atlas H-10 is the designation of a four-seater personal aircraft developed by Atlas Aircraft Co., a new South California firm. The firm's president, Max B. Marlow, was responsible for the design. The prototype has been completed and is undergoing flight tests. It is an all-metal low-wing monoplane with single fin and rudder unit and retractable tail-wheel undercarriage. The manufacturers hope to sell the H-10 for as little as $3,000, and production facilities are being acquired at Hemet, near Los Angeles. Powered with a 220-H.P. engine and grossing 3,200 lbs., the H-10 attains a maximum speed of 170 m. p. h. and cruises at 150 m. p. h.

● Hawker E.38/46 is the designation of a new experimental jet fighter which is basically a swept-back wing version of the Hawker N. 7/46. carrier-borne fighter. Like the N. 7/46, the new model is powered by a Rolls-Royce "Nene" turbo-jet of 5,000 lbs. thrust. Its speed is stated to be well over 600 m.p.h.

● Two SE 3110 helicopters are to be built by SNCA du Sud-Est. This model is a two-seater version of the SE 3101 single-seater experimental helicopter, which is undergoing flight tests at Villacoublay.

SAAB T 18B.

● The SAAB T 18B is a heavier-armed development of the SAAB B-18B attack bomber. Power plant of both types consist of two Daimler-Benz DB 605B liquid-cooled twelve-cylinder in-line engines developing 1,500 H. P., manufactured under licence by Svenska Flygmotor A. B. of Trollhättan, Sweden.



Zlin 26.

● The Zlin 26 is a two-seater trainer developed by the nationalised Otrokovice aircraft manufacturing concern in Czechoslovakia. A prototype has already been completed and is now undergoing flight tests. It is a low-wing monoplane of composite construction with fixed tail-wheel undercarriage. Power is supplied by a 105-H. P. Walter "Minor 4 III" air-cooled four-cylinder in-line engine. Span is 33 ft. 8 ins. and length 24 ft. 1 in. Gross weight is 1,666 lbs. and wing area 159.3 sq. ft., so that the wing loading works out at 10.5 lb./sq. ft. and power loading at 15.8 lb./H.P. Maximum speed is 130 m.p.h. at sea level, cruising speed 115 m.p.h. at 70 per cent. rated power, service ceiling 14,800 ft., and range 370 miles on cruising power.

● The I. Ae. 30 "Nancu" is a twin-engined single-seater fighter-bomber, a prototype of which has been completed by the Instituto Aerotécnico de Cordoba, the Argentine state aircraft factory. Flight tests are to start shortly. It is an all-metal low-wing monoplane with engine nacelles protruding unusually far

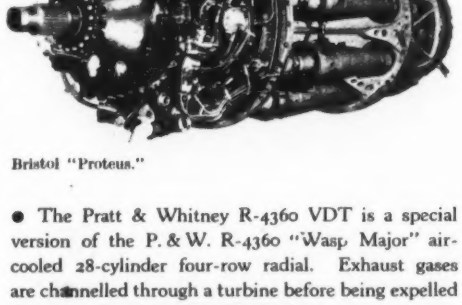
I.Ae.30 "Nancu."

from under the wing leading edge. Single vertical fin, elevators set high on the fin. Conventional tail-wheel undercarriage with main wheels retracting backwards and upwards into the nacelles. The "Nancu" bears a striking ressemblance to the de Havilland D. H. 103 "Hornet" long-range fighter: engine mounting and arrangement of radiators and oil coolers in the centre wing edge, and supercharger air intake, seem to have been taken over unchanged from the "Hornet."

● Differences appear notably in the tail design, arrangement of control surfaces and the design of the undercarriage. Powered by two Rolls-Royce "Merlin" 12-cylinder liquid-cooled in-line engines, each developing 1,800 H. P. and driving a four-blade controllable-pitch propeller, the "Nancu" is expected to reach a maximum speed of 435 m.p.h.

POWER PLANTS

● The Bristol "Proteus" propeller-turbine developed by The Bristol Aeroplane Co., Ltd., is mainly built up from a multi-stage compressor, eight combustion chambers disposed around the compressor casing, and two turbines for driving the compressor and the propeller. The compressor is a combined multi-stage axial and centrifugal unit. Its air entry duct is located on the rear side of the engine and the air passes through in a direction contrary to that of flight; it is passed to the combustion chambers when it reaches the centrifugal stage. Compressor and propeller drives are separate, each coming from an axial-flow gas turbine. The engine is started by means of two electric motors. Characteristics and performance are as follow: overall length (without exhaust cone), 99.75 ins.; overall diameter, 38.5 ins.; dry weight, 2,900 lbs.; maximum compressor r.p.m., 10,000; turbine/propeller gear reduction ratio, 11.11 : 1; shaft power at sea level, 3,200 H. P.; jet thrust at sea level, 800 lbs.



Bristol "Proteus."

● The Pratt & Whitney R-4360 VDT is a special version of the P. & W. R-4360 "Wasp Major" air-cooled 28-cylinder four-row radial. Exhaust gases are channelled through a turbine before being expelled through a jet pipe. The VDT gives a greater power output and has a notably lower specific fuel consumption than the ordinary R-4360—0.38 lbs./H. P. hr. against 0.48 lbs./H. P. hr. for the R-4360.

* Excerpts from Nos. 1498-1514 (July 27th to August 19th, 1948) of "Interavia Air Letter," an aeronautical digest published five times weekly, with photo service, in separate English and French editions.

● A more powerful version of the Mathis G 8r air-cooled eight-cylinder in-line engine is nearing completion at the plant of Mathis S. A., the French aircraft and automobile manufacturers. Output has so far been boosted from 190 to 220 H. P. Flying trials are to begin shortly.

INDUSTRIAL NEWS

● "Private enterprise does not exist in the British aircraft industry," asserted G. S. Lindgren, Parliamentary Secretary to the Ministry of Civil Aviation, in a House of Commons debate on July 27th.

● SNCA du Nord is building a series of 25 Nord 1400 "Noroit" twin-engined reconnaissance flying-boats at its Sartrouville and Le Havre plants.

● N. V. Verenigde Nederlandse Vliegtuigfabriken Fokker is to manufacture Gloster "Meteor" twin-jet fighters under licence. The Fokker licence makes provision for the manufacture of later marks of the "Meteor." The Dutch plant is to be transferred from its present site in North Amsterdam, to Schipol airport.

● The Glenn L. Martin Co. claims that within the next two or three years the U. S. Air Force will require 250 twin-engined transports as well as 500 multi-engined trainers.

● The fourth annual General Meeting of the International Air Transport Association was held from September 13th to 18th at the Université Libre, Brussels.

AIR TRANSPORTATION

● A 25 per cent. cut in return fares from New York to Europe, Africa, the Middle East and India was introduced by Pan American World Airways on October 1st. Reduced winter tariffs on Europe-U. S. A. runs have also been introduced by Scandinavian Airlines System and Sabena. K. L. M. Royal Dutch Airlines and British Overseas Airways Corp. are envisaging a 25 per cent. reduction of their round trip tariffs.

● Scandinavian Airlines System's surcharge for sleeper accommodation on trans-Atlantic Douglas DC-6 flights is $45, against $125 charged by other trans-Atlantic carriers.

● The joint SAS fleet now comprises 89 aircraft, including 16 Douglas DC-6s, nine DC-4s, 50 DC-3s, four Vickers "Vikings" and three Short "Sandringham VI" flying-boats. Four Boeing "Stratocruisers" and ten SAAB "Scandias" will be delivered in 1949.

● Major-General Hjalmar Riiser-Larsen assumed his new office as Managing Director of Det Norske Luftfartselskap on August 9th.

● The Russian Aeroflot airline has opened new services to the Balkans: Moscow-Belgrade (thrice weekly) and Moscow-Tirana (thrice monthly).

● The Soviet—Rumanian Transporturi Aeriené Romano—Sovietica (TARS) reports for 1947 an increase of 335 per cent. in the number of passengers carried and 1,186 per cent. in the quantity of freight delivered, as compared with 1938 operations.

● Four Lockheed L-749 "Constellations" will be included in the European Recovery Programme supplies for Italy if representation initiated by the Italian authorities succeeds.

● Exceptional concessions to Italian scheduled airline operators, retroactive to July 1st, 1947, are provided for in legislation which eliminates customs charges and taxation on revenue.

● Pilgrim flights to Italy during the 1950 Holy Year is the main subject of talks attended in Rome by Roy Chalk, President of Trans-Caribbean Airlines, the New York non-scheduled operator specialising in services between the U. S. A. and Italy. He believes that 250,000 pilgrims will come from the United States and 100,000 from South America during the Vatican Pilgrimage Year. His plans for financing a Vatican airline, to be known as Vatican Air Lines, were frustrated by a refusal of the Vatican authorities to allow an airline company to fly under the flag of the Vatican State.

● Transportes Aereos Portugueses opened a weekly Lisbon—Paris service with Douglas DC-4s on August 10th.

● A helicopter service for passengers between the Invalides City Terminal and Orly Airport, Paris, is being considered by the French Ministry of Transport and Public Works.

● Sabena is offering through tickets to the U. S. Pacific coast from Brussels under an inter-line agreement with United Air Lines. U. A. L. provides connections at New York San Francisco, Los Angeles and Seattle.

● Pan American Airways has been landing twice weekly at Stuttgart on its Frankfurt—Munich service since September 1st.

● British Overseas Airways Corp. and Air Ceylon (formerly Ceylon Airways) will start a pool service between Colombo and London as soon as the latter airline has received the Lockheed "Constellations" it has on order.

● Resumption of K. L. M.'s operations to Western Australia is expected to result from the visit of a Dutch technical delegation to Australia this month.

● A projected British Commonwealth Australia—South Africa route via the Cocos Island and Mauritius is receiving official attention.

● Canadian Pacific Air Lines plans to open a trans-Pacific route from Vancouver to the Orient and to Australasia by the summer of 1949. This would touch Alaska, Japan and China. Four Canadair DC-4M airliners have already been ordered for the purpose.

● Attempted piracy caused a "Catalina" of Cathay Pacific Airways to crash on July 16th, according to the sole survivor, who admitted that four men—including himself—ordered the pilot to hand over the controls to them just after the aircraft had taken off from Macao. In the ensuing fight, the pilot was killed and the "Catalina" crashed into the sea.

● The establishment of a civil aviation mission in Venezuela was announced by G. W. Rentzel, U. S. Civil Aeronautics Administrator, on July 29th. C.A.A. missions already exist in Peru, Colombia, and Bolivia, whilst negotiations are taking place for the setting up of a mission in Chile. These missions are mainly to assist South American countries in developing their civil aviation activities, and also to standardise aviation techniques and practices in the western hemisphere.

● Colombia, Venezuela, Equador and Panama are contemplating the formation of a joint airline, which might be known as Grand Colombian Airlines.

● Joint Chilean-Australian-New Zealand-British air services between Santiago de Chile and Sydney, via Easter Island, have been proposed by the Chilean Government. The Australian Government is examining the feasibility of the proposal.

● Air Safari is a new U. S. airline organisation planning to arrange air trips to East Africa. Groups of twenty passengers will be transported from New York to Nairobi in 38 hours.

● American Airlines has announced a cheap fare scheme to boost passenger loads on Mondays, Tuesdays and Wednesdays, on which days traffic is at its lowest. Described as a "first-of-the-week family fare plan," it permits wives and children under 21 to travel for half-fare on the three slack days, provided they are accompanied by their husbands or fathers. The project has yet to be approved by the C. A. B.

● The Port of New York Authority purchased Teterboro Airport, N. J. on August 12th, thus acquiring the fourth and final major commercial airport in the New York metropolitan area.

● Preparations for the Saro SR 45 flying-boat service to South America by British South American Airways are progressing. A Ministry of Civil Aviation survey party is leaving shortly to examine facilities in Brazil and other countries. There will only be one stop on the service to Rio de Janeiro, and there will also be a non-stop service to Bermuda.

SERVICE AVIATION

● A review of USAF aircraft procurement appropriations for the 1948-1949 fiscal year shows that the North American B-45 jet bomber is the most expensive aircraft, each machine costing $1,966,000. There are three other aircraft types costing over $1,000,000 each, namely, the Boeing C-97 "Stratofreighter" transport ($459,000), the Boeing B-50 bomber ($1,447,000) and the Lockheed C-121 (Model 749 "Constellation") ($1,274,000). The most expensive fighter is the North American F-86 jet ($379,000), followed by the Republic F-84 "Thunderjet ($274,000). Cost of other aircraft is as follows: Fairchild C-119 transport, $900,000; Grummann SA-16 amphibian, $832,000; Northrop C-125 "Raider" transport, $359,000; Fairchild C-82 "Packet" transport, $343,000; Lockheed TF-80 jet trainer, $270,000. Least expensive aircraft ordered is the Sikorsky H-5F helicopter, at $87,000.

● The USAF has laid down more specific terms for aircraft previously known as fighters or bombers. There are four types of fighter aircraft: (1) the "Penetration Fighter" for operations deep into enemy territory against enemy aircraft and ground targets; (2) the "All-Weather Fighter," replacing the night fighter class, for operations not only at night but also during inclement weather; (3) the "Interceptor Fighter" for high-speed, short-endurance operations required for local defence against enemy bombers and guided missiles; and (4) the "Parasite Fighter" to be attached to very long-range bombers and released for flight only when combat is imminent. For bomber aircraft there are three categories: (1) the "Light Bomber," a high-speed ground support aircraft operating from bases 400 to 600 miles from the front lines; (2) the "Medium Bomber" for operations from bases 2,000 to 2,500 miles from the target; and (3) the "Heavy Bomber" for operations against strategic targets deep in enemy territory.

● The U. S. Navy is intensifying its air crew training programme so as to qualify all flying personnel for all-weather and night operations. Two new squadrons have already been activated for such operations from aircraft carriers.

● Construction of the U. S. Navy Permanent Guided Missile Test Centre at Point Mugu, Calif., was started on October 1st. The project will involve an expenditure of $50,000,000 and the programme should be completed by 1953.

● Transport aircraft of the Royal Canadian Air Force are now making two or three flights monthly between Canada and the R. A. F. Transport Command Base at Lyneham, Wiltshire.

PHOTO CREDITS:

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Great Britain:
Bristol Results

C

* The Bristol Aeroplane Co. Ltd., reports... that during the year an additional associated company was incorporated under the title British Messier, Ltd., to develop and market a range of undercarriages and accessories based on the well-known French Messier designs. The Bristol Aeroplane Co. has a 50 percent interest in this company.

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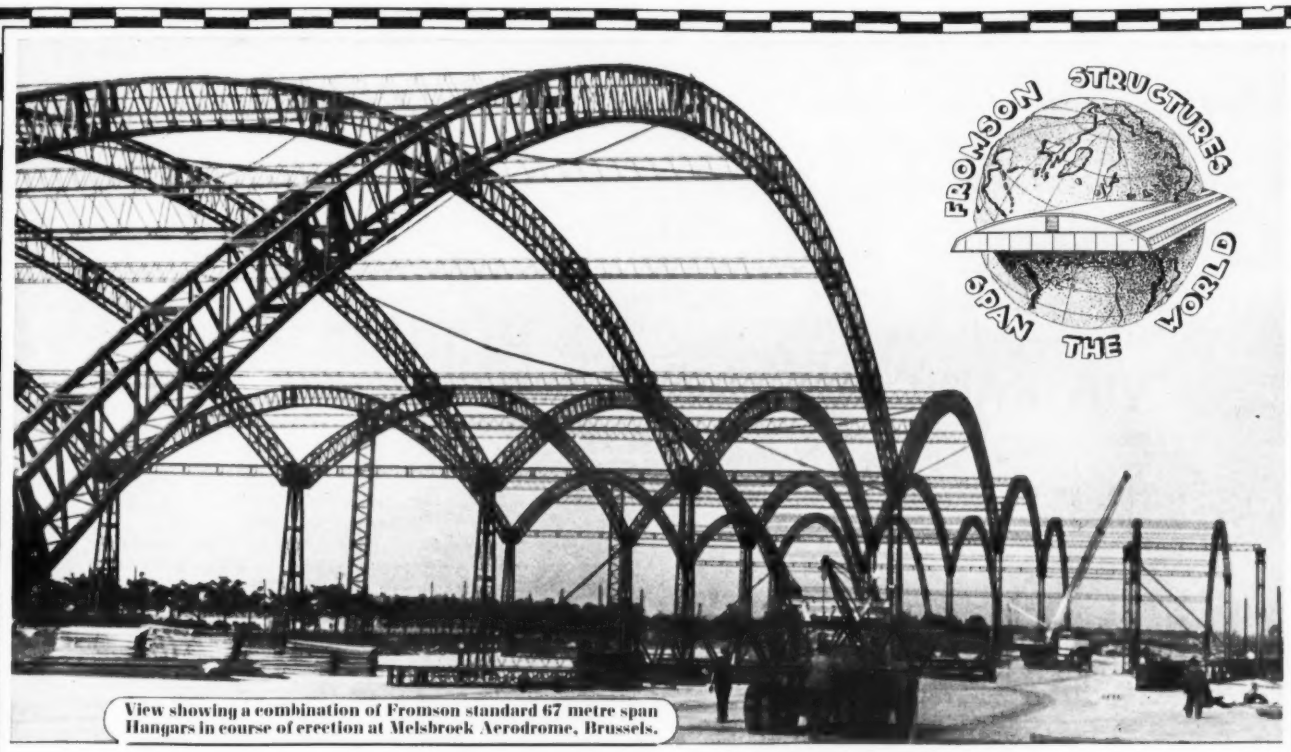

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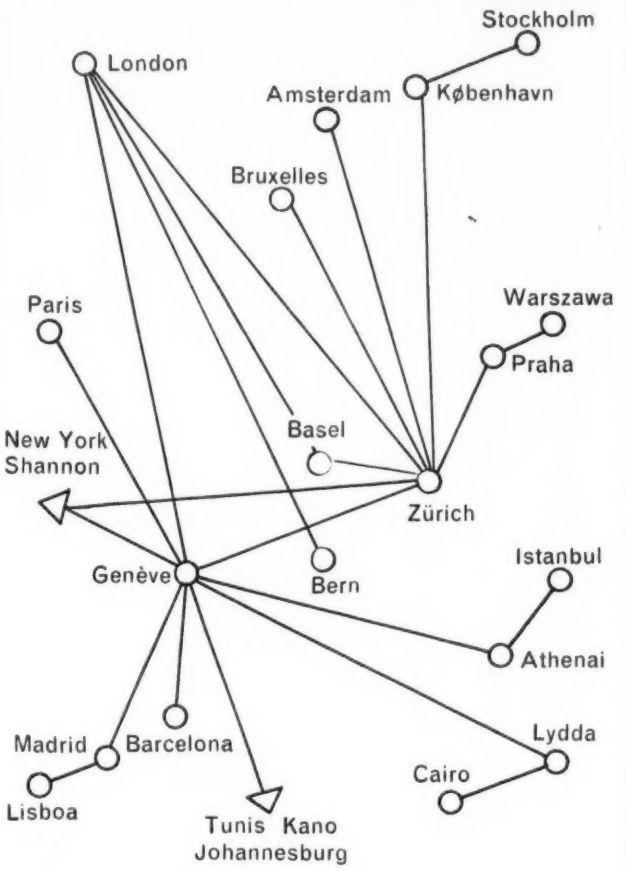

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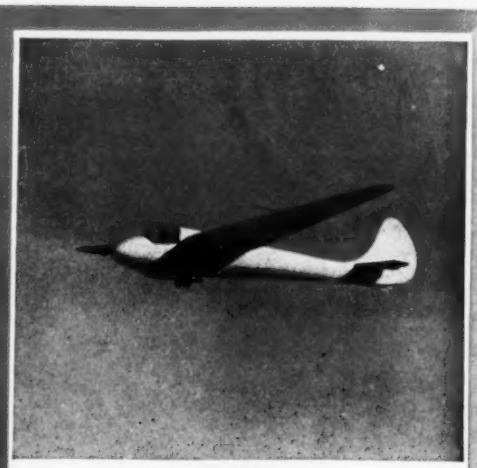

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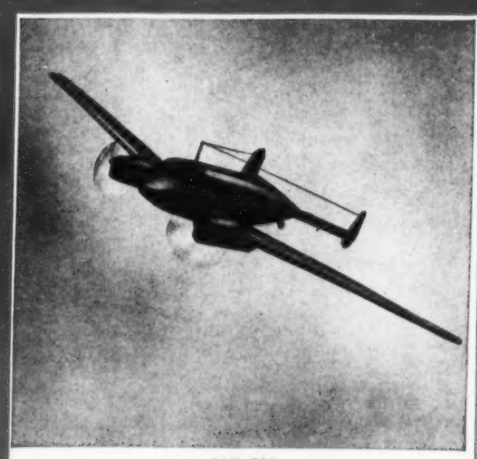

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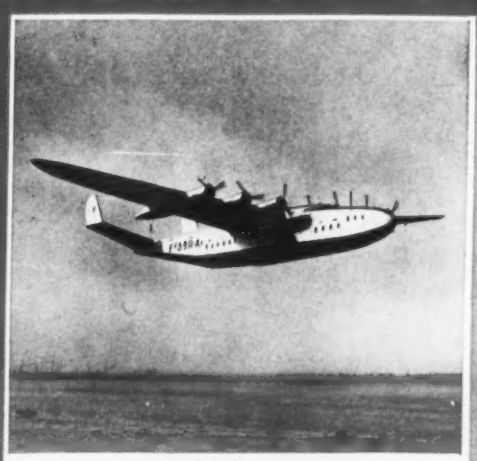

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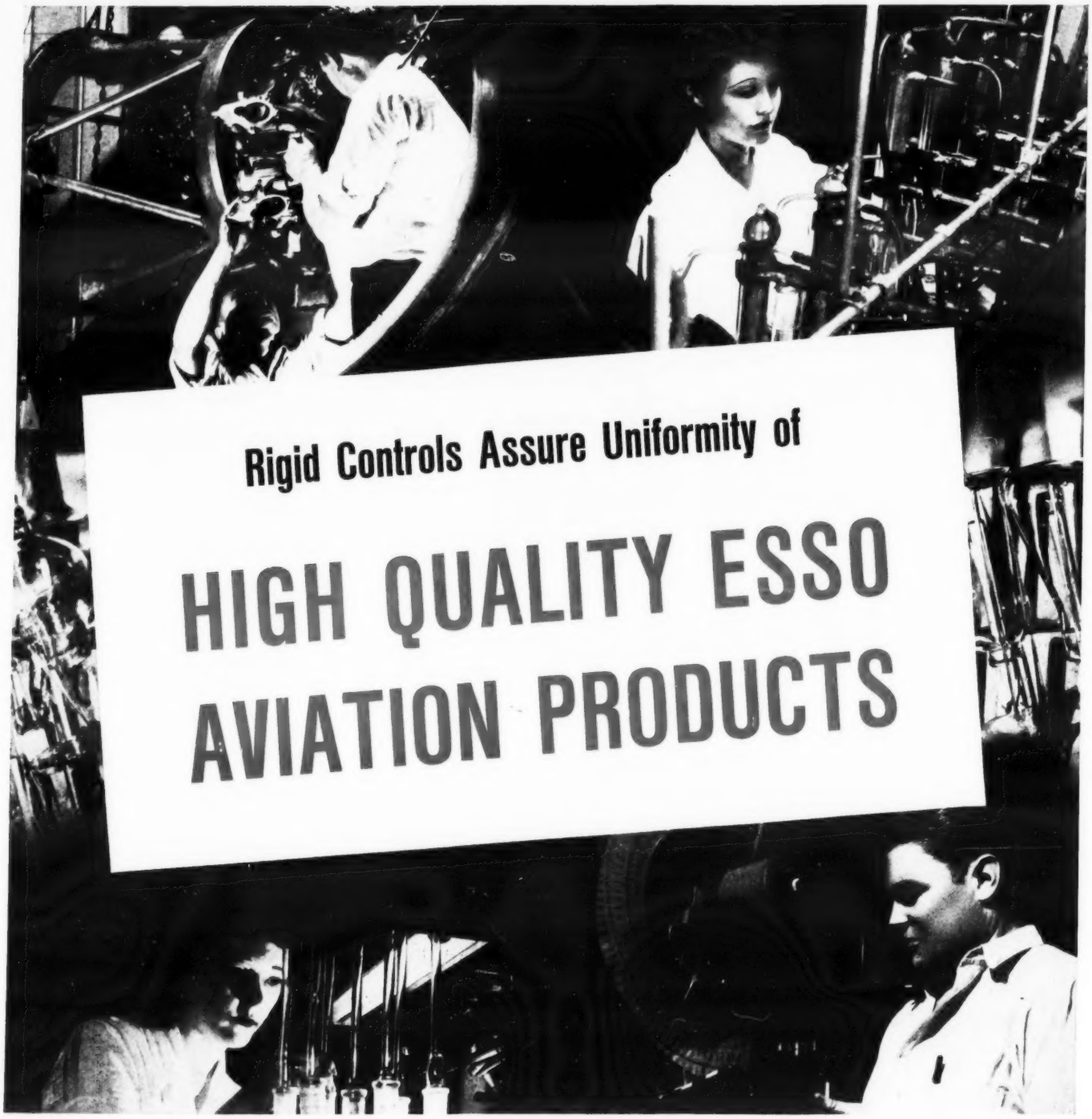

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